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BRIDGES AS ILLUSTRATIVE MATERIAL ON THE PARALLELOGRAM OF FORCES.[1]

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The parallelogram of forces is far from being neglected in modern courses in elementary physics, but the students who have a vivid idea of its meaning and practical importance seem to be few and far between. Many times, in giving laboratory examinations in physics, I have asked some student who had just finished satisfactorily the familiar three spring balance experiment, what it was good for, and why any one might conceivably be glad to know the fact that he had just proved. I have still to find a boy who instinctively thought of looking ten feet over his head at the trussed roof of the laboratory. It is, therefore, my hope to emphasize once more the familiar fact that there is a wealth of practical applications of the parallelogram law that can be used to show students what this law is really good for. Among the more obvious of these applications are derricks, where the parallelogram law can be applied at the tip of the boom to determine the necessary strength of the boom hoist. There are also steam shovels, where the scoop is moved in any desired direction, against the resistance of the material that is being handled, by a push along a beam and a pull along a chain. The student should be led to see how the resultant of these two forces can be made to point in the desired direction and to be of the necessary magnitude. There are also kites, sailboats, and aeroplanes, where the pressure of the air against a surface has a component in such a direction as to propel the sailboat or to support the kite or aeroplane. There are hanging street lamps, hanging signs, guy-ropes on tents, and often guy-wires on telegraph poles where the wires have to turn a corner, and dozens of other applications that you will find if you look for them. But the commonest and perhaps the most interesting of all are to be found in the various roof and bridge

[1] Read before the Physics Section, C. A. S. & M. T., Hyde Park High School, Chicago, Nov. 27, 1914.

trusses that abound in every neighborhood. It is chiefly of these that I wish to speak. Many of the details that I shall mention are perhaps too technical for class room use, but others are, I believe, entirely suitable for even the most elementary classes, and you will know better than I where the dividing line should come.

It is best to begin with what is called a "pinned" truss (see figure 1) rather than a "riveted" truss (see figure 2). In a pinned truss the members are provided with holes at each end, and are joined by pins, from three inches to two feet in diameter, which



FIG. 1. A pinned truss, a cantilever Pratt.

are thrust through all the holes at a joint, like the pin of a door hinge. No twisting or bending can be transmitted through such a joint; the members are able only to push or to pull on the pin. In a riveted truss there are gusset plates at each joint, that look like the webs between a duck's toes, to which the members are fastened. The distinction between riveted and pinned trusses is not fundamental, in that all riveted trusses are designed as if they were pinned, the gusset plates being counted on merely to increase the stiffness of the truss.

It is also best to begin with a "simple truss," that is, one in which all the members are so arranged as to form triangles. Such a truss depends for its stiffness on the familiar fact that a triangle is determined when the lengths of its three sides are fixed, while a quadrilateral or other polygon can be deformed without changing the lengths of its sides. The experimental truss in figure 3 is a simple truss in this sense.

This experimental truss has proved to be very useful both for lecture demonstrations and for experimental tests of computed stresses, but many of the points that will here be demonstrated with its help, could be taught equally well by referring one's students to various real bridges in the neighborhood. The model is made of 1¼ inch 22 gauge aluminum tubing, with cast aluminum end pieces at the joints. These castings are of two kinds, "central" and "offset," and are interchangeable and reversible, so that three members can be brought to a single joint without throwing the tubes out of alignment. This is important because the truss is built double (see figure 5) so as to be self-supporting, and it is desirable to be able to use one width of cross brace throughout. The truss should not be thought of as two trusses with a roadway between, but rather as what is called a "pony truss," which can stand alone without cross bracing above the road bed. The pins are 14-inch lengths of thin tubing 7/16 of an inch in diameter and fit somewhat loosely in the ½



FIG. 2. A riveted truss, a Warren truss with divided panels.

inch holes. The standard members are 3, 4 or 5 feet long, so as to form right triangles and at the same time make the arithmetic easy. The whole truss is made as light as possible (32 pounds for the twelve foot span shown in figure 3, and 49 pounds for a similar fifteen foot span with double diagonals, in the middle panel) so that the effect of such concentrated loads as are easy to handle may not be masked by the effect of the weight of the truss itself.

Now let us consider how the laws of statics apply to such a truss as that in figure 3. Two treatments are possible. In the first we neglect the weight of the truss itself and work only with the concentrated loads (in this case two fifty-pound weights), and later eliminate the weight of the truss in making the corroborative measurements. In the second we take the weight of the

truss into account as we go along. The second may seem more reasonable at first, but it is harder to do. It is also less practical, for engineers, in designing a large truss, always neglect the weight of the truss as such, concentrating at the pins what experience has taught them will be an equivalent set of loads in addition to the expected pin loads due to other causes, such as the weight of the road bed, and of any wagons, crowds of pedestrians, or trains that may use the bridge. Then they compute the stresses that the members will have to stand, and design them to suit. And finally they check up the weights of these members and make sure that they are not in excess of the concentrated loads used to represent them. Let us use the first method and neglect the weight of the truss itself.

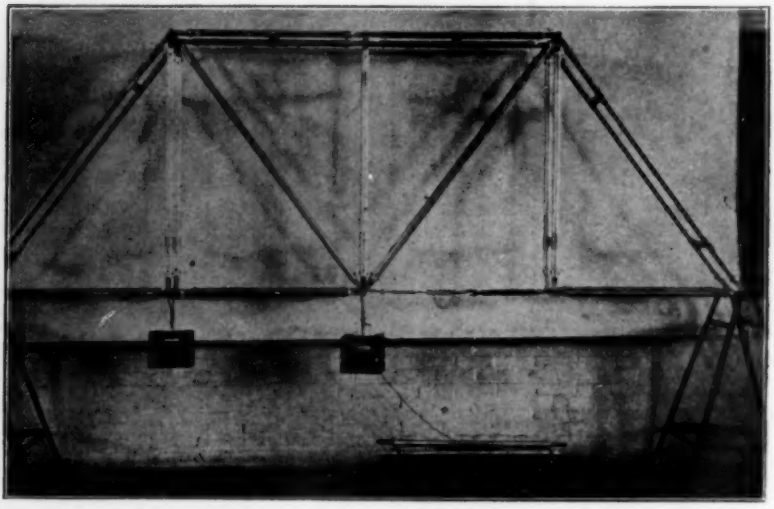


FIG. 3. An experimental model—testing a tension member.

We begin by computing the vertical reactions exerted *on* the truss in figure 3 *by* the supports; evidently the right hand pier must push up with a force of $\frac{1}{2}\,50+\frac{1}{4}\,50=37.5$ lbs., and the left hand one with $\frac{1}{2}\,50+\frac{3}{4}\,50=62.5$ lbs. As a check, we notice that $37.5+62.5=100=50+50$ lbs.

Next we "isolate" the right hand lower pin. By this I mean that we draw an auxiliary diagram of this pin by itself, magnified so that we see clearly just what we are talking about, and we show by arrows on this drawing all the forces exerted *on* the pin by the pier and the two members, and no other forces (see figure 4a). We have one force of 62.5 that is completely known,

and two others, P and T, that are known in direction but not in magnitude. The parallelogram of forces (see figure 4b) gives us the magnitude of P and T. Since either triangle in figure 4b is similar to one of the 3-4-5 triangles of the truss itself, T is $\frac{3}{4}\times 62.5 = 46.9$ lbs., and P is $\frac{5}{4}\times 62.5 = 78.1$ lbs.

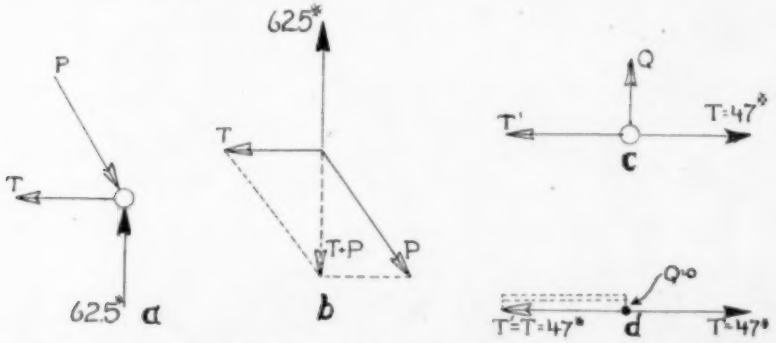


FIG. 4. Insolation sketches [(a) and (c)] and the corresponding parallelogram diagrams [(b) and (d)] for the first two pieces to be treated in the truss of figure 3.

This brings us to an aspect of real bridges that often interests students more than any other. Evidently the horizontal and inclined members that meet at the right hand pier have very different parts to play in the structure. The horizontal one has to pull on the pins at its two ends, and is said to be "in tension," while the inclined member has to push against the pins at its two ends, and is said to be "in compression."[2] In a large bridge this difference in function would involve a great difference in appearance between these members. The horizontal tension member would be composed of one or more steel straps or rods, enlarged at the ends to give room for the holes, as in the foreground of figure 5, while the inclined compression members would be much stouter and more complicated, as in the background of figure 5, so as not to buckle under compression. I have found that every one who has mastered this distinction has thereafter watched bridges with a new interest, noticing at once which members were built for compression and which for tension, and trying to find out why.

Having finished with the first pin we may proceed to the pin next to it in the bottom chord of the truss. Here (see figure 4c), the known force is T = 47 lbs. found above, and there are

[2] Notice that no member can possibly push at one end and pull at the other.

two unknown forces. The parallelogram of forces (figure 4d) turns out to have shrunk to a line, one side, Q, being zero. So $T^1 = T = 47$ lbs., and the second member in the bottom chord is in tension, while the first vertical is not stressed at all in this loading of the truss. If there were a concentrated load at this pin as well as at the other two, this vertical would, however, have its part to play like the rest.

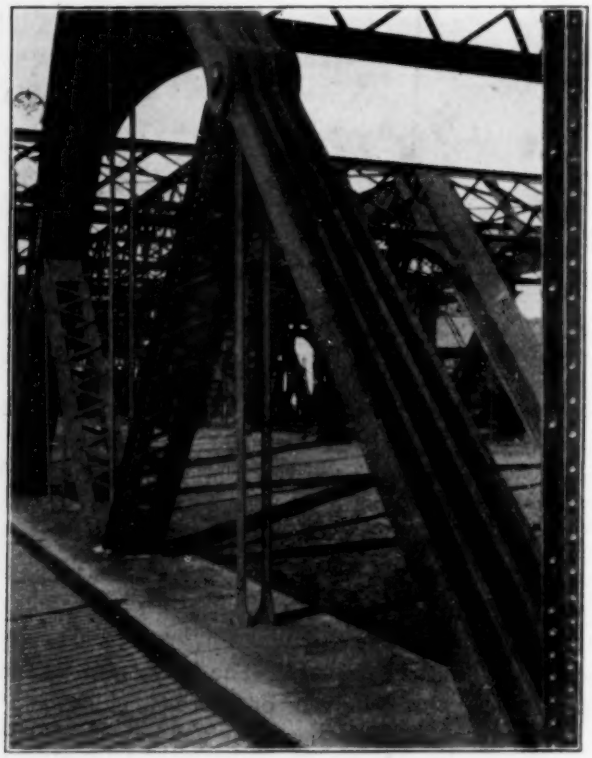


FIG. 5. Typical tension and compression members.

We could proceed next to the pin directly above this one, where we would find two known and two unknown forces. We would have to use the parallelogram of forces twice here, once to compound the two knowns into a single resultant, and again to determine the unknowns from this resultant as before.[3] We would thus find the top chord member in compression and the diagonal in tension. And so we could go on through the whole truss, pin by pin, determining the nature and magnitude of the

[3] Unless we use the equivalent process called the polygon of forces.

stress in every member, although three or four pins are usually enough to illustrate the point at issue.

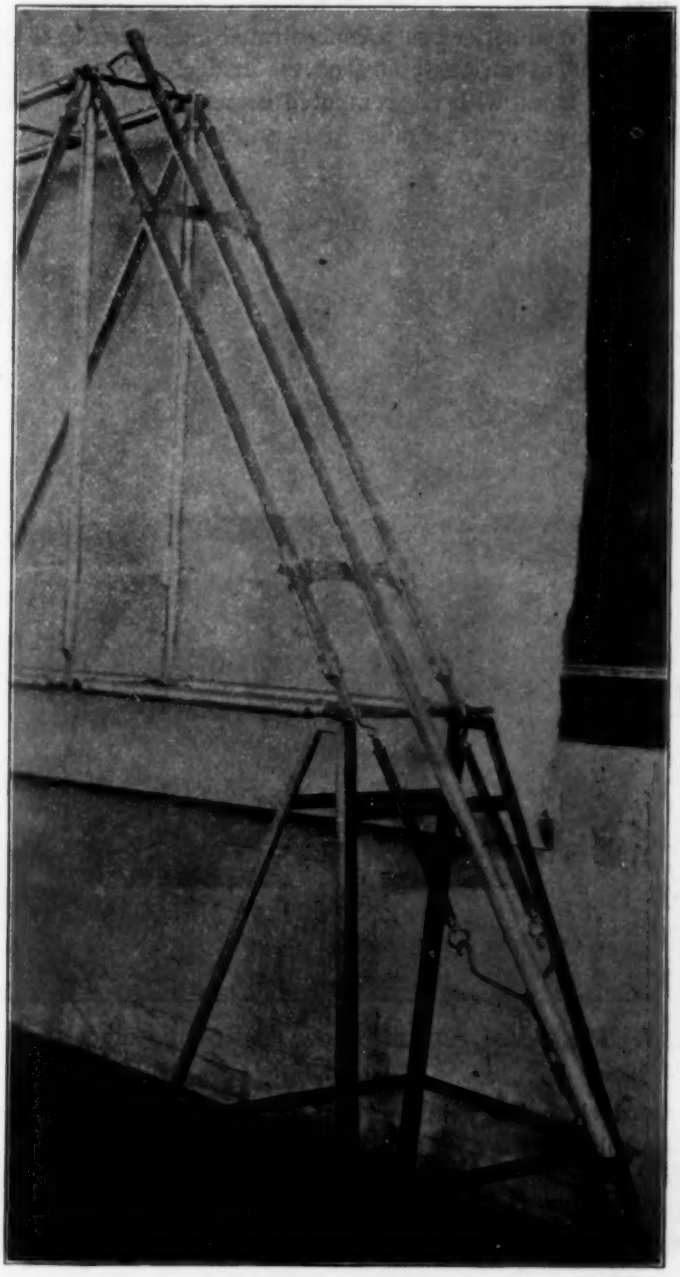


FIG. 6. Testing a compression member.

Computations of this sort can be tested on real bridges by means of a sensitive instrument called an extensometer, which measures the stretch in a tension member, or the shrinkage in a compression member, when a concentrated load, such as a locomotive, is put at various points on the bridge. These measurements often agree with the computed values to something like a tenth of one per cent. Similar tests on the model can be made

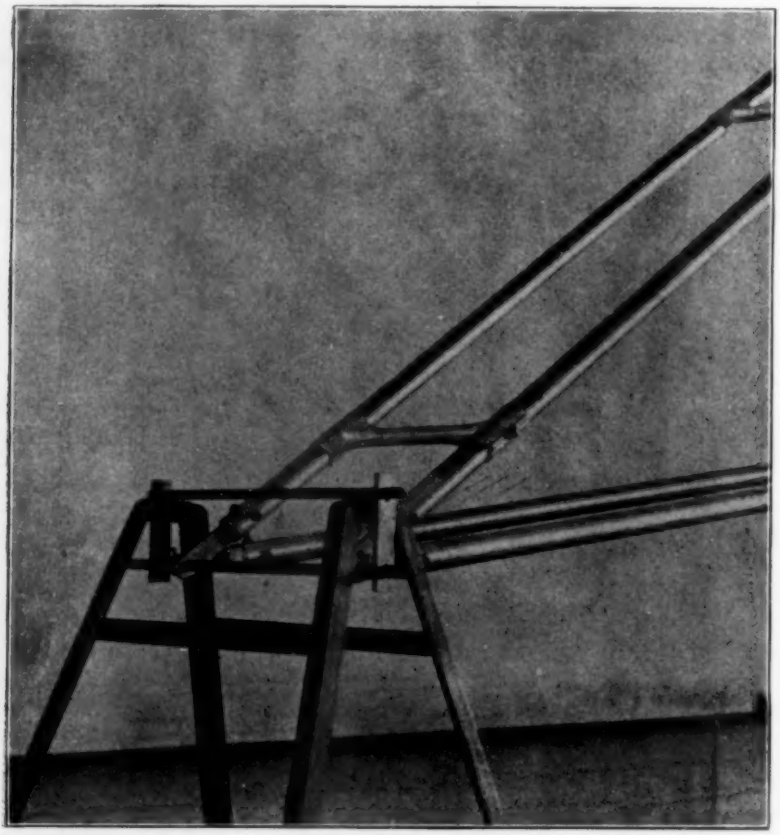


FIG. 7. Method of supporting one end of the model to avoid friction.

by the devices shown in figures 3 and 6. In figure 3 a pair of spring balances have been stretched between the two pins at the ends of a tension member, and a turn-buckle tightened until the pins are just pulled loose from contact with the tension member in question. Just the right tightness is secured by watching when the tension member begins to rattle when shaken.

When the balances are adjusted, the tension member can be removed altogether, as in figure 3, to make the demonstration more striking. In figure 6 one of the end diagonals is being tested for compression. An auxiliary piece of aluminum tubing supports the balances in such a position as to pull the two pins apart, and the same turn-buckle is used to tighten the balances until the member rattles when shaken. In both cases readings of the balances should be taken both before and after the concentrated loads are put on. The difference between the two sets of readings gives the stress due to the concentrated loads by themselves, the effect of the weight of the truss being eliminated. Such tests will usually come out within two per cent of the calculated values.

In testing the model truss it is necessary to take one precaution. We have assumed that the reactions at the supports are vertical. But if the truss rests on solid supports and gives a little under a concentrated load, there will be frictional components at the ends large enough to make a noticeable difference in the tests. In real bridges there is a corresponding difficulty, not only from the truss's stretching under load, but also from thermal expansion. To avoid this, one end of a real truss is usually supported on rollers. In testing the model the equivalent arrangement shown in figure 7 is more convenient.

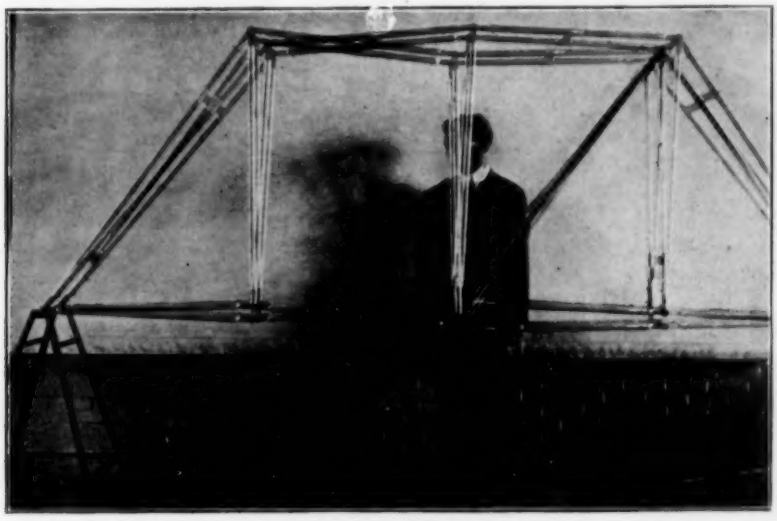


FIG. 8. Double exposure showing how truss deforms when falling.

There are two other interesting points that can be demonstrated with the model, "pin-packing" and "the shear in a panel." By pin-packing is meant the way in which the various members that come to a joint should be arranged on the pin there. If the two members that bring the greatest forces to a pin are widely

separated on the pin, they evidently have a considerable tendency to bend the part of the pin that lies between them, since they are like a couple with a large lever arm. If they lie close together, as they should, the lever arm is much smaller. In other words, in a well packed joint, the forces exerted by the members should balance each other as far as may be, not only for the joint as a whole, but for all the various groups of adjacent members considered separately. This matter is hard to explain on paper, but on the model, where one can see things in three dimensions, it is very simple.

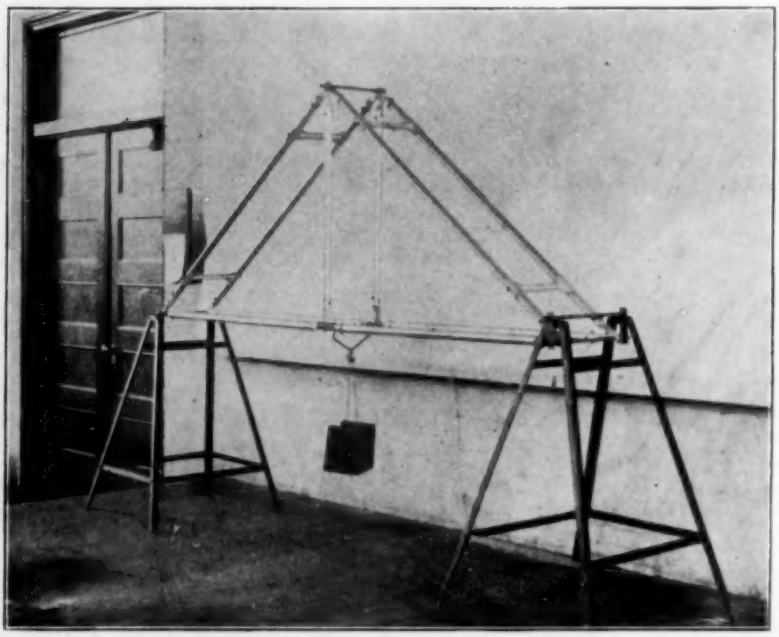


FIG. 9. King post bridge truss.

To demonstrate the "shear in a panel," one removes one of the internal diagonals of the truss, say the left hand one in figure 3.[4] The truss will then collapse, unless supported by the demonstrator. This can be done in this particular case either by pulling *up* on the middle pin, or by pushing *down* on the pin on the other side of the panel. The reason is evident from figure 8, which is a double exposure. It shows that when the middle pin drops, the side pin rises, and so we can support the truss by preventing either of these tendencies. If we want to make the truss rigid, we can put in an additional member along either di-

[4] The truss will be easier to handle if all concentrated loads are removed first.

agonal of the panel; but if it springs from the middle lower pin, it will be in tension, while if it springs from the side lower pin, it will be in compression. Another way of looking at this is to notice that when the rectangular panel deforms in figure 8, one diagonal lengthens and the other shortens. A tension member along the first diagonal, or a compression member along the second, will keep the truss in position.

If a truss of this sort has all its diagonals so set as to be in tension, it is called a Pratt truss; if all the diagonals are in compression, it is called a Howe truss. When it was common to make the compression members of a truss of wood, and when the iron rods for the tension members were expensive in comparison, Howe trusses with long diagonal compression members and short vertical tension members, were common. Now that steel mem-

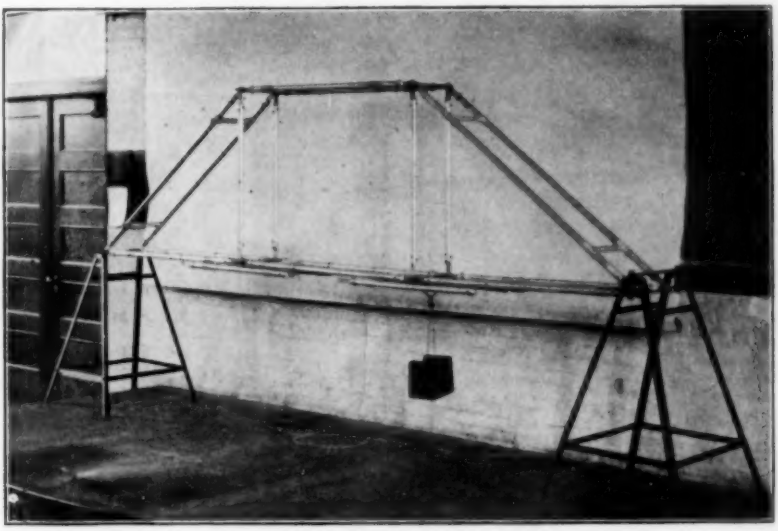


FIG. 10. Stiffened Queen post bridge truss.

bers are commonly used, compression members are much more expensive than tension members (see figure 5) and most trusses are Pratt trusses.

This brings us to the question of "counters" or crossed diagonals, such as are found in the middle panels of most bridges. A little consideration, and particularly a little experimenting with the model, will convince one that a concentrated load on any pin except the middle pin of a Pratt truss, will *tend* to put every diagonal between the load and the middle of the truss in compression. If the concentrated load is large enough in compari-

son with the weight of the truss, the stresses in some of these diagonals will actually "reverse," and they may buckle, unless designed as compression members. Now it is usually cheaper to build two tension members than one compression member, and so the middle panels, where reversal will come first, have crossed diagonals, one of which slackens off, while the other takes up the whole shear in the panel.

It should be noticed that the likelihood of reversing the shear in a given panel depends, not on the absolute size of the largest expected concentrated load, but on its size *relatively* to the weight of the truss itself. In real bridges conditions are usua'ly such as to make counters necessary only in two or three panels near the middle. But if models of these bridges are made for laboratory experiments, their weight will be smaller in comparison with the loads they can carry, and counters may have to be provided in all the panels, unless the diagonals can stand some compression, as in the model here illustrated. This is an interesting example of the fact, well known to engineers, that the weights of very large spans increase faster than their strengths, so that there is a pretty definite limiting length of span, beyond which no truss could carry even its own weight, to say nothing of any road-bed or traffic.

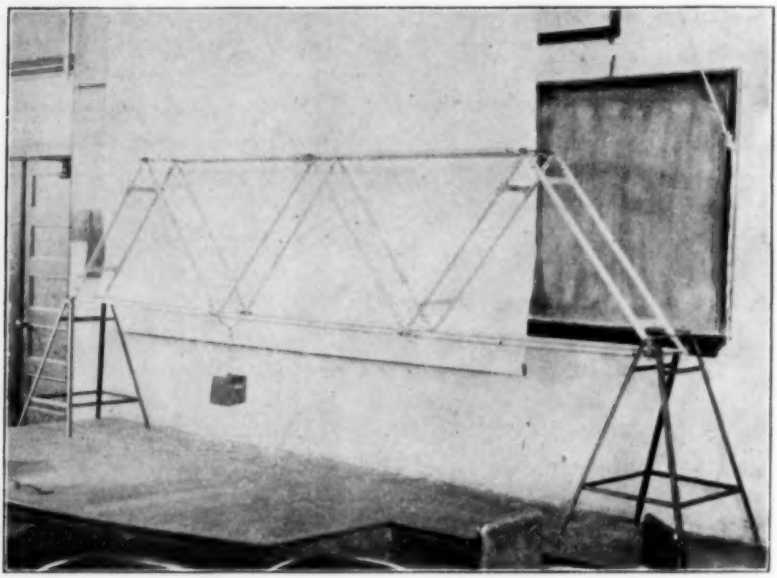


FIG. 11. Warren truss.

All this can be demonstrated on one set-up of the model. If additional members are available, or time can be taken to dismantle the model and set it up in a new form,[5] many other interesting trusses can be demonstrated. Thus figure 9 shows a King post truss that is common in all small country bridges. The

[5] This takes from one to two hours for complicated forms which require rearrangement of the end castings.

inclined members are in compression, and are ordinarily wooden timbers. The vertical is in tension, and is ordinarily an iron rod. Figure 10 shows a Queen post truss. It is not a pure truss, in that it would collapse under nonsymmetrical loads if the lower chord were hinged at the two pins. The truss is used to stiffen a beam which otherwise might not be strong enough to carry its load. How effectively it does this is shown in the figure, where a load of fifty pounds is carried on a twelve foot span by a lower chord formed by tying on a couple of extra members with hemp string. Queen post trusses are common in country bridges, and inverted Queen post trusses are especially common under freight cars.

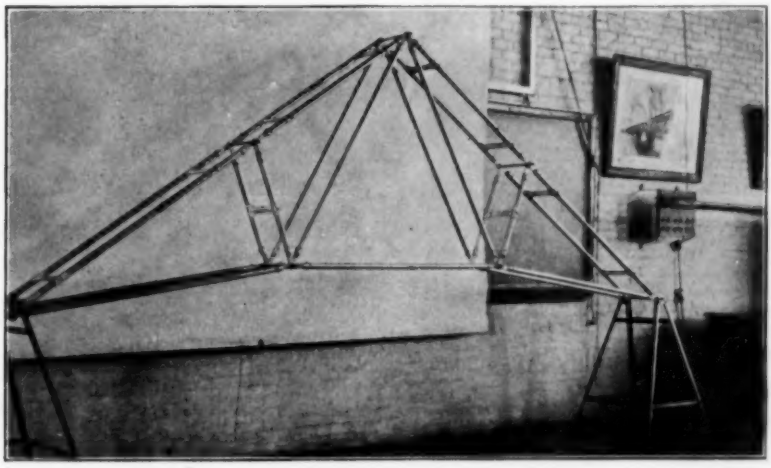


FIG. 12. Belgian or Fink roof truss.

Figure 11 shows a form of bridge truss called a Warren truss. Its disadvantage is that all the inclined members have to be built as compression members, since reversals of stress in them are frequent. Multiple Warren trusses, in which several independent sets of isosceles triangles are superposed, are common, both in steel trusses and in the old fashioned wooden "covered bridges" of New England. The truss in figure 2 would probably be called a Warren truss with divided panels. And finally, figure 12 shows a common form of roof truss. Often each of the roof slopes is divided into four or even six panels, instead of two, each panel having a tension diagonal. This truss is convenient, in that the two halves of a rather large span can be built separately in the factory and shipped on flat cars, so that but little work of erection is left to be done in the field.

SEWAGE DISPOSAL.[1]

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Civilization and education has been accompanied by a wonderful growth of cities and has made the problem of sewage disposal one of civic, state and national importance. Sanitation becomes of greater importance as communities become more congested.

It is only of late years that this question has received proper attention, the greatest progress having been made in the last few decades. The combined efforts of the scientist, chemist and engineer have been called upon to help solve this problem of ever increasing importance.

Improper disposal of sewage has caused directly or indirectly a large percentage in the typhoid mortality rate.

The gathering of large numbers of people calls for additional safeguards and means of sanitation. In some instances sewage can be disposed of by dilution, discharging direct into large bodies of running water; but most streams are as a rule not of sufficient size, or are already so polluted that additional sewage would increase the burden, already too large.

Generally sewage is diluted with the entire water supply of a city and is a dirty appearing water containing a greater or less percentage of organic matter. There is usually enough organic matter present to make it disagreeable and to cause odors. The presence of various disease germs also makes it a source of pollution to water bodies.

In general, all methods of sewage treatment employ the principle of reduction through microscopic organisms. Bacteria of various kinds attack the organic compounds reducing them to simpler forms, doing so through successive stages. Reduction takes place through two classes of bacteria, namely aerobic (thriving in the presence of oxygen) and anaerobic (thriving in the absence of oxygen).

The most prevalent form of getting rid of sewage is by dilution. Where the stream is sufficient in size to allow proper oxidation the sewage will be properly taken care of without objectionable odors. Such a stream however should have a flow of about 300 cubic feet per minute for each 1,000 inhabitants. Instances where disposal by dilution alone is sufficient are not many and

[1] Report of the Indiana Academy of Science.

usually some additional treatment is necessary, suitable to local conditions.

If the stream into which the sewage is to be discharged allows of partial dilution, treatment by some properly designed form of tank may be sufficient, but tank treatment alone will not always suffice. Tank treatment is but a step in the purification of sewage and should usually be followed by some form of filtration or after treatment. Various forms of tanks can be used but

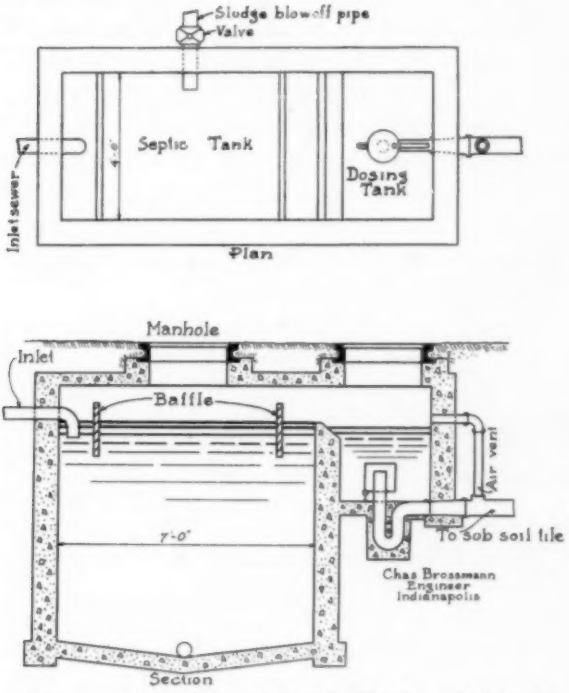


FIG. 1. Plan and Section of Septic Tank suitable for medium sized residences.

the type and size that insures the best results can only be determined after proper investigation of all conditions—as the number of people, amount of sewage, the rate and the time of flow, the location of adjacent property and the size of the water course into which the treated sewage is finally discharged; all are important and enter into the proper solution of this important question.

Tank treatment therefore is essential as the first step in sewage reduction, and is necessary in order to retain and break down the

solids, but it must not be supposed that it purifies the remaining sewage liquor. The tank treatment is necessary in preparing the sewage liquor for further purification. Such tanks can be made in the form of plain settling tanks, a septic tank, or a combination of both.

The public will universally call any tank (even a cesspool) a septic tank, and usually they believe that a septic tank absolutely purifies the sewage. Such is not the case, a reduction from thirty to sixty per cent of suspended matter, and around thirty per cent in organic matter, is usually what takes place. The tank will not take care of very fine particles or colloidal matter. Such matter (colloidal) being in condition just between suspension and solution. The best results are obtained when the solids are taken out or retained as quickly as possible and the subsequent liquor remaining immediately treated. It is important that liquor be not retained too long or it will become in a toxic condition. Time is an important element in the proper design of a tank, also the state of the sewage in reaching the tank.

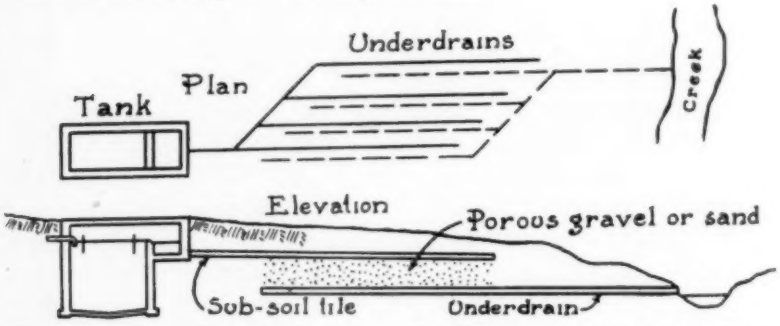


FIG. 2. Plan and Section showing Septic Tank and Subsoil Filter.

Septic tanks are usually designed for a rate of flow, of from eight to sixteen hours. The more modern type of tank with two compartments one for settling and one for sludge digestion, are usually designed with a rate of flow of half (or even less) than the above. The septic tank is usually a rectangular shaped chamber with several baffle boards, extending across to break the flow of the sewage. Such tanks should be covered as the organisms that break down the solids (known as anaerobic bacteria) thrive best in the absence of air and light. Septic tanks usually take some time to become operative, a scum mat forming at the top and sludge at the bottom. At intervals such tanks must be cleaned of the sludge. It was formerly supposed that just as

much solid matter was turned to liquid and gas to offset the amount of solids coming in, however it has usually been found necessary to clean out the resultant sludge at intervals.

The Imhoff type of tank consists of two chambers, one for settling and one for the deposit and digestion of sludge. Such a tank, while somewhat more expensive than the plain tank is smaller and will give more uniform results, besides offering better means for after treatment of the liquid and assuring a better solution of the sludge problem.

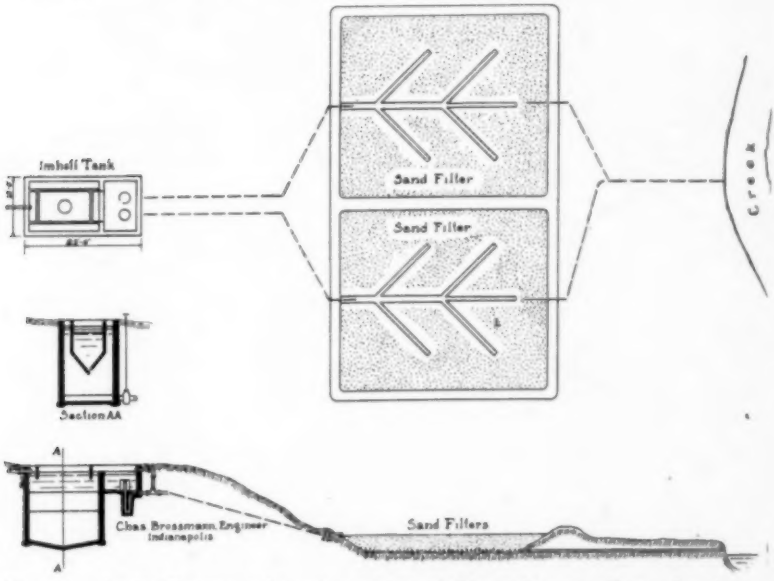


FIG. 3. Imhoff type of tank and sand filter for small institutions. (Indianapolis Country Club.)

This type of tank has an upper settling chamber with a slotted opening at the bottom. The sewage in flowing through the upper chamber deposits the solids into the sludge chamber below. In the sludge or digestion chamber below, the solids and organic matter is gasified and liquefied independent of and without disturbing the settling matter above.

The gases of decomposition and the constant agitation in the lower part does not disturb the sewage in the settling chamber, furthermore albumen from the fresh sewage is not constantly added to the septic sludge; hence there is less odor and the sewage liquor is delivered in a fresher condition for after treatment. The sludge from this type of tank dries out quicker, is in better

condition for disposal, has less water content, and has different characteristics than sludge from a shallow tank which is kept in



FIG. 4. Imhoff tank showing sludge formation at sides. Settling chamber in center. Dosing chamber in foreground. Sewer inlet shown at far end. (Julietta, Ind.)

constant contact with the sewage. Such double tank sludge soon becomes spadable like garden compost.

The tank treatment should be followed by dilution or some form of filtration. In some cases the sewage liquor from tanks

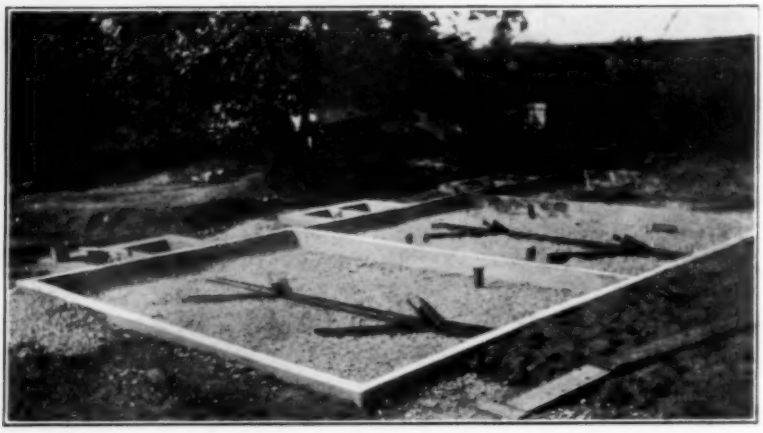


FIG. 5. Contact filters of stone. (Julietta, Ind.) Sewage is discharged from tank, Fig. 5, to these beds.

can be discharged into a water course. Usually it is necessary to use some form of filter or nitrification bed. This can be done in the following manner:

(1) In small plants by discharging the sewage into tile laid near the surface of the ground. Such ground must be suitable for the sewage to percolate through to a subdrainage system below. Such ground should be gravelly or of sand.

(2) By discharging the sewage into contact beds, viz.—a water-tight bed, filled to a depth of several feet with broken stone or other hard material, the sewage being automatically discharged on to the bed, retained a fixed period, and then discharged from the bed. In such a bed absorption and oxidation of the organic

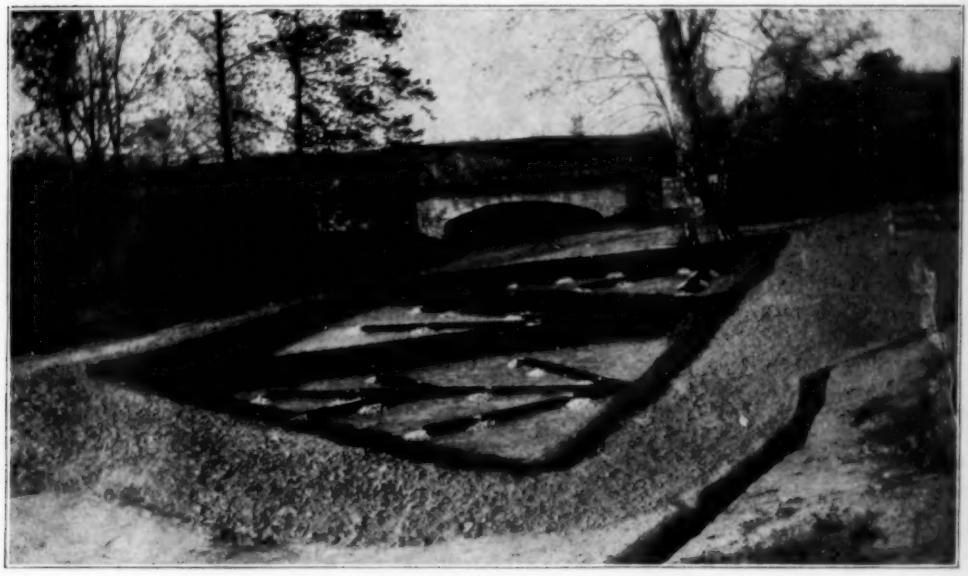


FIG. 6. Sand filters (Julietta, Ind.) Sewage is discharged from contact beds, Fig. 5, to these sand beds. This is the last step. The purified effluent is clear and odorless.

matter is accomplished by aerobic bacteria, viz., those which thrive in the presence of air.

(3) Sand filters. The sewage from tanks can be discharged on sand filters—automatically dosed as in contact beds. Such sewage covers the surface of the bed and gradually works through to the underdrains below, the action being that of filtration and nitrification. If a very pure effluent is desired the sewage can be discharged from the tank to the contact bed and then be treated through the sand filters. In a properly designed plant this will give a very clear effluent.

(4) Sprinkling filters. In the larger plants sprinkling filters are largely used. These consist of beds of broken stone, usually of a depth of 6 feet or more and are arranged for good underdrainage. The sewage is automatically discharged over the top of the bed by sprinkling nozzles; trickles down through the stone and out through the underdrains. Such beds can be worked at a higher rate than any of the preceding methods, hence a smaller area is required, which makes this method more adaptable for large installations.

Disposition of Sludge.

The real problem in sewage disposal plants is the sludge problem. Engineers are just learning how to make sludge but in most cases have not found a satisfactory solution in disposing of it. In larger plants the sludge question is the stumbling block.

Sludge may be roughly divided in two classes, that from shallow tanks and that from deep tanks. Sedimentation tank sludge



Fig. 7. Ducks swimming in small run (100 feet below plant) into which purified sewage discharges. (Julietta, Ind.) This photo taken after plant was in operation two years. Before plant was installed all water fowl died from drinking the water.

is a black semiliquid mass which on being exposed to the air becomes offensive, giving off much gas and odor. The water contained from such sludge is usually 90 to 95 per cent.

The sludge from septic tanks ranges all the way from 8 to 45 cu. yds. per million gallons of sewage. Septic sludge which has been retained in tanks for a number of months undergoes a great change. The organic matter is attacked and partly gasified and liquefied which reduces the amount of sludge. Such sludge in well operated tanks is a concentrated mass containing from 80 to 90 per cent of water; there is not as much odor to septic tank sludge as to the fresh sludge from the plain settling tanks.

Imhoff or two story tanks give a sludge that has different characteristics than either the plain settling tank or septic tanks. Such tanks being much deeper the sludge seems to become thoroughly

impregnated with minute gas bubbles which are under pressure due to the depth of the tank. When this sludge is allowed to flow out the liquid content seems to flow off quicker due to expansion caused by these gas bubbles. Such sludge becomes spadable in about a week's time or over and is easily handled and is usually without odor. The water content is also not as great as in the older type of tank.

Screens.

In recent years there have been great improvements in the mechanical screening of sewage. In this line some of the German plants have developed some especially effective devices. One of the best being of the revolving screen type, which have shown under tests a removal of from 60 to 70% and even a still higher percentage in the solids of suspension. These screens must not be compared with the ordinary bar screen, which is of different construction as the revolving screen is constantly cleaned by rotating brushes and is hence more efficient.

The above outlines the principal methods of sewage disposal. It must however be borne in mind that the proper method is wholly decided by local conditions. Care must be exercised in order that the various factors affecting the problem be carefully considered.

A fuller realization of the Sewage Disposal problem is being evidenced throughout the country as the years go by, both by the state and health officers and city officials. The state has done a great deal of preliminary work in the way of sanitary surveys and this work should be heartily indorsed and commended. However there is still much to be done and undoubtedly some method of maintaining public control of the streams will have to be devised before the question of pollution can be properly taken care of.

There are so many different factors entering into this question that the best solution can only be worked out with a proper organization which will take into consideration every phase of the question and which can reach every district, affected, whether this territory be in one or more states. The state authorities should be given the power to pass upon every sewage disposal problem and they should have the proper means and support for doing this.

A NEW LOCKER SYSTEM FOR CHEMICAL LABORATORIES.

By W. J. Bray,
Normal School, Kirksville, Mo.

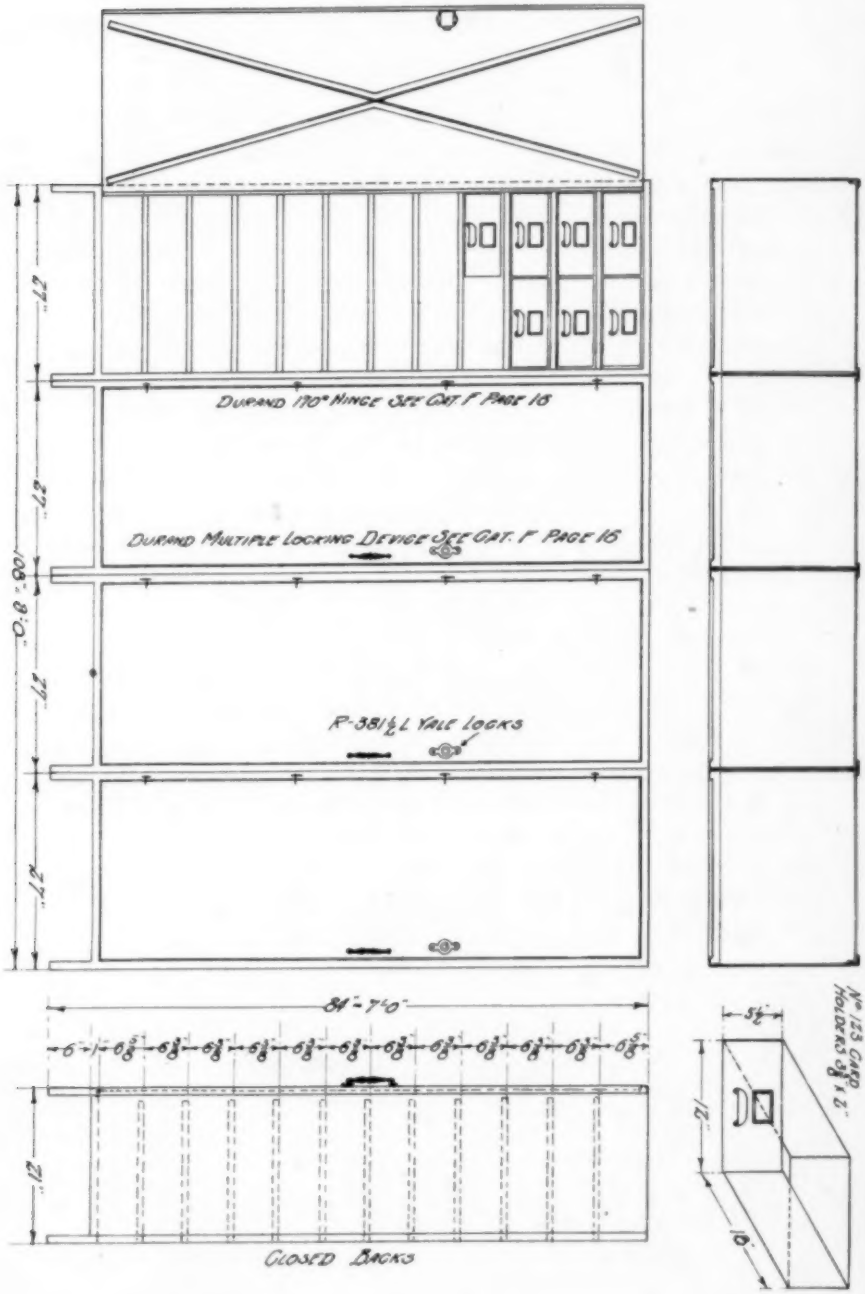
Prior to the summer of 1913 our chemical laboratory was equipped with 64 of the usual type of wooden drawer lockers. The demand for more space became almost imperative. We had to have more locker room, but could not get it in the laboratory and we could get no more of the old wooden lockers installed. It was under these conditions that I planned the system here shown. Having heard of nothing similar, I take this means of giving others the advantage of my experience. The drawings, as well as the lockers themselves, were made by the Durand Steel Locker Co., of Chicago, Ill., to fit my specifications.

Our system consists of a steel cabinet of four sections, each section having a door with a lock. Each section has twelve shelves. On each shelf two of the steel boxes, shown in the drawing, are placed. Each box has a card rack on the front in which is placed the assignment card. The entire system is made of strong sheet steel, enameled, and is very rigid and well made. It is shipped knocked down and is set up, by being bolted together, in the laboratory. By this system we have increased our locker room from 64 to 94, and can increase it more at our pleasure by adding extra sections, without increasing the size of the laboratory. The cabinet is placed along one wall of the room.

Each box is large enough to hold all of the apparatus needed by the student except ring stand and reagent bottles. These we keep in the old wooden lockers, one set to each desk. Each student, on entering the laboratory at the beginning of a course, is assigned to one of these steel lockers. He then carries it from its place in the steel cabinet to the desk assigned and fills out card to be placed in the rack in the front of the locker. This card is of the following form:

DEPARTMENT OF CHEMISTRY.
FIRST DISTRICT NORMAL SCHOOL, KIRKSVILLE, MO.
Name .....
Class .....Lab. Hrs. .....
Locker No. .....Desk Top No. .....Date .....

The checking card is compact and convenient, and has, on the top, blanks the same as the card shown above. Below these blanks is the list of apparatus. The student may either leave the


DURAND 170° HINGE SEE CAT. F. PAGE 16
DURAND MULTIPLE LOCKING DEVICE SEE CAT. F. PAGE 16
P-381½L YALE LOCKS
6'-8"
27"
27"
27"
27"
84"-7"0"
6"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"-6⅞"
12"
CLOSED BACKS
5½"
12"
10"
1½" 123 GARD HOLDERS 3½" X 2"

steel locker on the top of the desk to which he is assigned while he is actually working in the laboratory, or he may place it in the top drawer of the old wooden system. At the close of the laboratory period the student carries the steel locker back to the steel cabinet and puts it in its proper place, when the instructor again locks the door. The door is locked all of the time except at the beginning of the period, when the students are getting out their apparatus, and at the close, when they are replacing it. The instructor carries the only key, a master key for all four locks. When he wants to use his locker, the instructor opens the door for him, and relocks the door as soon as his box is out. Those familiar with the management of a chemical laboratory will appreciate the relief from the problem of the student losing or forgetting to bring his key.

After eighteen months of use of this system, we have yet to find a single reason to regret having had it installed. The lockers are fire, mouse, and dust proof, and easily kept clean. Sponges, ring stands and reagent bottles are kept in the wooden drawers. The enamel on the lockers will last well and there will be little trouble from rusting.

If I were to have more of these cases made, the only change I should care to make would be the addition of a card rack, 8 inches by 4 inches, on the inside of each door. In this rack I should place a card with lines numbered 1 to 24 inclusive on which I should have placed the name of the student responsible for each locker. I find that this would increase the convenience of the system. These cases are a source of satisfaction to us, and I am glad to recommend them to others. If I can aid any one by answering questions concerning the scheme I shall be glad to do so.

Associate Professor Horatio H. Newman, of the Department of Zoölogy in the University of Chicago, has been engaged to give before the College Endowment Association of Milwaukee, Wisconsin, a series of four lectures on the general subject of "The Social Life of Animal Communities." He will discuss in the opening lecture parental care, mutual aid, and social life among animals. In the second lecture will be considered community life among bees and wasps, and recent discoveries concerning their habits and intelligence. In the third lecture Professor Newman will discuss ant communities, their agriculture, armies, battles, and slavery; and in the last, the most complex insect communities—termites or white ants.

GAS FLAMES AND GAS EXPLOSIONS.

By W. F. Roecker,

High School of the University of Wisconsin.

a—Woulff bottle, two-neck.

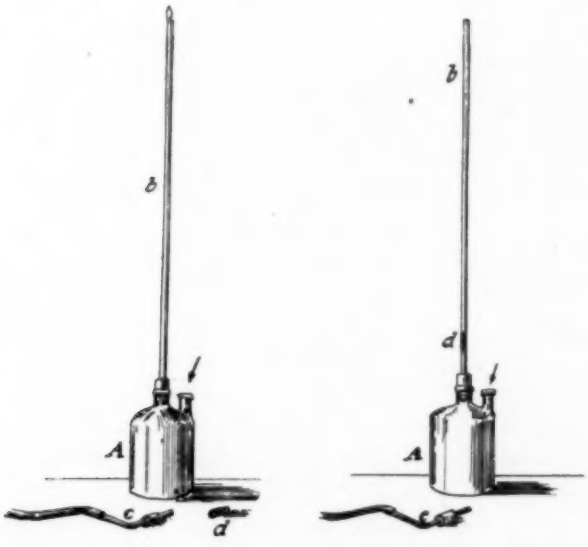
b—Glass tube, 1 m. long, 1 cm. diameter.

c—Glass and rubber connection to gas jet.

d—Fine mesh copper gauze, 1 cm. wide, loosely rolled into a cylindrical plug.

With the apparatus here indicated the nature, luminosity and propagation of gas flames and the nature and prevention of gas explosions may be quickly and effectively demonstrated.

In both cases the apparatus is attached to the gas jet, the gas is lit at the end of tube (b) [with the proper precautions], the large yellow flame is adjusted to a height of about 5 cm., and the apparatus is disconnected by removing (c); do not turn off the gas until (c) has been disconnected. In case II, (d) is placed in tube (b). The Woulff bottle may be partly filled with sand to give it stability.



Case I demonstrates the following points:

1. The luminosity of a gas flame is decreased and finally vanishes as the amount of air mixed with the gas is increased.

2. If the air supply is increased further a point is reached at which the flame is self-sustaining and begins to be propagated in

the direction of the gas supply. This explains the "striking back" of Bunsen burners.

3. The increase in speed of propagation down tube (b) shows that a further increase in air supply increases the rate of propagation until the speed becomes almost instantaneous so that the mixture flashes or explodes.

Case II demonstrates in addition that

4. A flame can not be propagated through a good conductor because the burning gas is brought below its kindling temperature by it. This explains the action of the Davy lamp. To prove that the explosive mixture was really there in case II, hold a burning candle at the opening for (c).

Facts incidental to this experiment but of interest in this connection are:

1. Air is about twice as heavy as illuminating gas.

2. Illuminating gas begins to flash when mixed with air 1 to 5, is most explosive when mixed 1 to 6 or 7, and becomes non-explosive again when the proportion exceeds 1 to 12. This explains in part why well ventilated mines are free from explosions.

3. A gas explosion travels faster than sound.

The great advantage which this apparatus offers is that the flame is visible at every stage of the experiment. It is adapted from Blochman's Luft,. Wasser, Licht und Wärme.

NEW APPARATUS FOR FALLING BODIES.

By A. A. Upham,

State Normal School, Whitewater, Wisconsin.

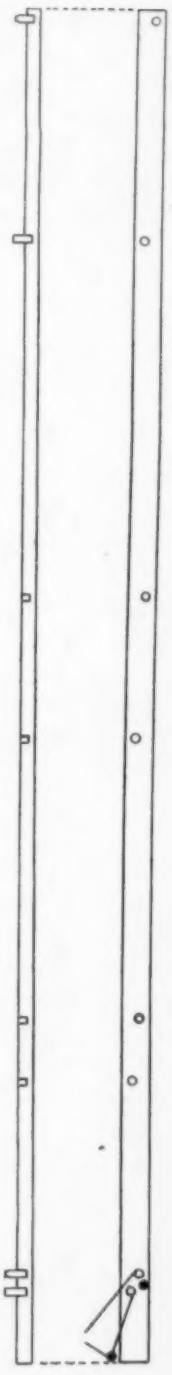
The apparatus about to be described is new, only in that it is compared with Galileo's inclined plane used three hundred years ago. It has been used by the writer for twenty-five years. So it is about as new, relatively, as a year old automobile.

The device consists of a common 2″x4″ scantling, Figure 1, sixteen feet long, if the room in which it is to be used is high enough. If the room is lower, a shorter piece must be used and only three falls can be observed. The scantling should be cut exactly the right length to spring into place between the ceiling and the floor and remain fixed. Two rows of holes are bored in one of the 4″ faces, to receive wooden pegs about five-eighths of an inch in diameter and two to three inches long. The rows should be one inch apart. Up to the pegs of one row an iron or

brass ball is drawn by a No. 20 white thread and allowed to fall by releasing the end of the thread from the fingers. The pegs of the other row (the left hand row) support pendulums which swing from their highest to their lowest points and strike the falling balls at the lowest point. Of course, only one pendulum and one ball are used at the same time, there being four sets.

The pegs over which the thread is drawn to raise the falling balls are grooved an eighth of an inch deep, one-eighth of an inch from the outside end. The pendulum pegs have a thin saw kerf one-fourth inch deep in the middle of the outer end through which the thread for the pendulum ball passes. They go into the holes with some friction and may be turned slightly if necessary to raise the pendulums or adjust the ball so that it rests against the falling ball at its lowest point. The pendulum ball is the same size as the falling ball, and is drawn back by a two or three inch thread, by the same thumb and finger that holds the thread supporting the falling body. Fastening these two threads together and burning them apart has been tried, but there is no advantage in this method. The fingers should be dry and a little push may be given to the pendulum thread as it is released so that the pendulum gets well started before it pulls the thread out of the fingers. The pegs for the falling balls are placed at distances of a trifle more than one, four, nine, and sixteen feet from the floor.

The length of the first pendulum is 9.77 inches, and the others are four, nine, and sixteen times as long respectively. It is well to let the pegs for the longest pendulum and the highest ball remain in place, attaching the pendulum thread and slipping it through the slots of the lower pegs. Another pair of pegs is all that is needed, as they can be replaced in the successive holes as used. The scantling must be plumbed so that the balls will strike at the bottom. A



long pole with a piece of leather around one end forming a shallow cup is used to elevate the ball to the highest peg. It seems to be less amusing to the pupils than a step ladder. The pendulums are of such length that they make the journeys from their highest to their lowest points in 1/4, 2/4, 3/4, and 4/4 of a second respectively. Thus the pupil has demonstrated to him the facts that a body falls one foot in one-fourth of a second, four feet in two-fourths, nine feet in three-fourths, and sixteen feet in four-fourths of a second (nearly). It is not necessary to explain further how from one or all of these facts the acceleration and laws of falling bodies are "derived." There is no figuring on the relative height and length of a plane or relation between force and mass, as in the Atwood's machine. It is not claimed that this is a better thing than a fine falling body apparatus, for college work, but for elementary physics it certainly introduces the student to a method of measuring the time of a very rapid motion with considerable accuracy and shows what is meant by such expressions as "The velocity varies as the time," and "The space fallen varies as the square of the time." When he has seen these relations it is easy for him to understand that a body falls, in one second, sixteen feet, in two seconds, sixty-four feet, and in the second second forty-eight feet.

The writer has a modification of this device consisting of two vertical wires on which a carrier holding an electro magnet slides. The magnet is in series with another one at the bottom which holds back the pendulum ball. The upper magnet holds up the falling ball and when a switch is opened both balls are released from the magnets at the same time. By careful adjustment the falling ball may be made to strike the pendulum exactly at its lowest point as shown by the loose ball bounding off at right angles to the plane of the wires. The pendulum ball, in this case, is suspended by a fine German silver wire attached to a support which slides on the two wires and is held in place by two thumb screws, common binding posts being used both for this and the magnet support.

NEW BUILDINGS AT UNIVERSITY OF CHICAGO.

The new Julius Rosenwald Hall at the University of Chicago, devoted to the work of the Departments of Geology and Geography, is now receiving its equipment and will be formally dedicated at the Spring Convocation. The building, with its equipment, has cost about $260,000 and has admirable facilities not only for instruction but for advanced scientific investigation.

HEIGHT OF CLOUDS AT SUNSET.

By Edison Pettit,
High School, Minden, Neb.

Perhaps everyone has noticed that for some time after sunset the clouds which are still lit by the sun, because of their great altitude, gradually fade through varied shades into a dark purple as the earth's shadow rises, producing an altogether pleasing aspect. The higher the cloud, of course, the longer will it be saved from the folds of the earth's evening cloak. Evidently the height of the cloud is a function of the time required for the earth's shadow to cover it after the sun has set for an observer anywhere on the earth's surface. However, because the sun does not set perpendicularly to the horizon this time varies with the declination of the sun and with the latitude of the observer. By applying the proper equations the altitude of a cloud in the evening may be determined with so simple an instrument as an ordinary watch.

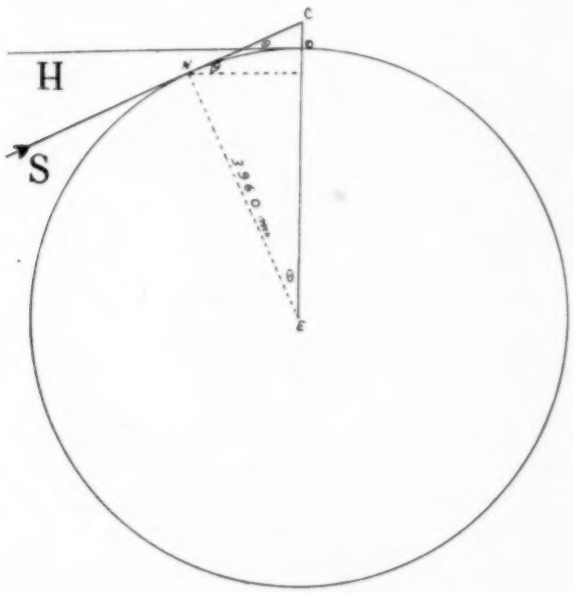


Fig. 1.

In the solution of the problem it will be convenient to note that the altitude of the cloud is directly dependent on the angular distance of the sun below the horizon at the instant the earth's shadow strikes the cloud and that this value which we may call θ

is dependent on the time t after sunset, the altitude of the observer λ, and the sun's declination, δ. This is shown in Fig. 1.

Let E be the earth's center, o an observer, c a cloud, S the sun, and Ho the plane of the horizon. The shadow of the earth will strike c when Sc is tangent to the earth's surface at N. Then θ will be the sun's angular distance below the horizon, and $\angle$ NEO will also be equal to θ. Under these conditions (1) $h = 3960 \frac{1-\cos\theta}{\cos\theta}$ where $h = oc$. This simple formula gives the value of h when θ is known We must obtain θ, however, from t, λ and δ. Fig. 2 shows how this may be done.

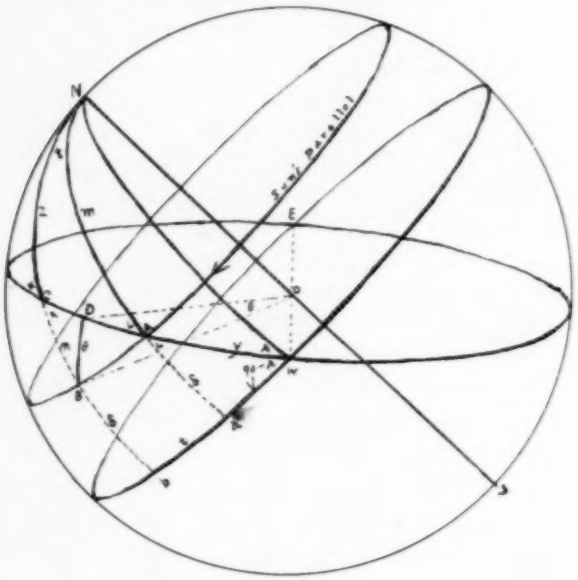


FIG. 2.

In Fig. 2, let NS be the axis of the celestial sphere, o the observer, CDAW the horizon, W the west point, Wab the celestial equator, AB the sun's parallel, A the sunset point, B the position of the sun at the time the cloud is extinguished by the earth's shadow, θ the angular distance of the sun below the horizon at this time, t the angular distance the sun moves in this interval after sunset measured with a watch and reduced to degrees, and NW, NA, and Nb hour circles. $\angle$ NWA is equal to λ and hence $\angle$ AWa is equal to $90° - \lambda$.

We will solve the right spherical triangle BCD for BD $= \theta$.

In triangle BCD

(2) $\sin\theta = \sin n \sin k$.

But from the figure.

(3) $n = 90° - (z+\delta)$, for which the value z may be obtained from $\triangle AcN$ in the following equations applying to an oblique triangle.

$$(4)\begin{cases} \tan\frac{1}{2}(z-\delta) = \dfrac{\sin\frac{1}{2}(l-t)}{\sin\frac{1}{2}(l+t)}\tan\frac{1}{2}m, \\ \tan\frac{1}{2}(z+\delta) = \dfrac{\cos\frac{1}{2}(l-t)}{\cos\frac{1}{2}(l+t)}\tan\frac{1}{2}m. \\ [m = 90° - \delta,\ \cos l = \cot y \tan\delta,\ \text{where } \cos y = \cos\delta\cos v]. \\ z = \frac{1}{2}(z-\delta)+\frac{1}{2}(z+\delta). \end{cases}$$

Also the value of k is given by

(5) $\cos k = \sin\lambda\cos(v+t)$ in which the value of v is

(6) $\sin v = \tan\lambda\tan\delta$.

The values are computed in the order

$\rightarrow v, k, y, l, m, z, \theta$ and h by the respective formulas. In equation (4) where the function t appears it must be in angular measure. Since t is of relatively small value, usually minutes of time, the conversion to degrees and minutes is,

(7) $t_o = \left[\frac{t}{4}\right]^\circ + [15r]'$, where r is the remainder of the division of t by 4, and t is expressed in minutes. h will be in miles. To take as an example.

Minden, Nebraska, June 8, 1914.

Observations on a flocculent cloud nearly due south and overhead.

$$\lambda = 40°\ 28', \quad \delta = 22°\ 49', \quad t = 15m. = 3°\ 45'.$$

The following results are obtained:

$v = 21°\ 2'$.	$l = 44°\ 46'$.	$\theta = 1°\ 59'$.
$k = 53°\ 54'$.	$m = 67°\ 11'$.	$h = 2.376$ mi.
$y = 30°\ 39'$.	$z = 86°\ 38'$.	

In applying this formula it will be noticed that theoretically the cloud should be in the zenith, however the earth is so large compared with h that the result is only slightly affected. Let us see the effect on a cloud at the horizon, the point where HO and SC intersect. Obviously here the altitude of the sun below the horizon is $\frac{\theta}{2}$, hence the height of a cloud in the zenith for an observer is $h' = 3960\ \dfrac{1-\cos\frac{\theta}{2}}{\cos\frac{\theta}{2}}$. Applying this to the present

problem $\frac{\theta}{2} = 1^\circ\ 59'$, $h' = 0.7922$ mi. Hence the true height h' computed from the above formulas is three times too great and must be multiplied by the factor .3331 for correction.

If the cloud is in the north or south the only value affected is λ, which is of only slight consequence. In applying this method to the study of the heights of clouds observations should be made on the clouds near the meridian and of considerable altitude to secure close approximations.

PAPPUS'S SOLUTION OF THE DUPLICATION PROBLEM.

By James H. Weaver,
High School, West Chester, Pa.

In Hultsch's edition of the Collection of Pappus (Pappus Alexandrinus, Collectio, Hultsch, apud Wiedmannos, 1867) there are several discussions of the three famous problems of geometry. The duplication problem is discussed in Book III (Hultsch, pages 31-69, 165-177), and in Book VIII (Hultsch, pages 1071-1073). In Book IV (Hultsch, pages 235-303) there is a large list of theorems bearing on all three problems.

The following is a solution of the duplication problem as given by Pappus himself. He seems to be very fond of it, for he gives the same discussion three different times (Hultsch, 67-69, 165-177, 1071-1073). In the second reference (165-177) he gives the following proof and construction, and then shows that the solution is the same as that of finding two mean proportionals.

Let there be a circle ABC about the center D, whose diameters ADC and BDE are perpendicular to each other and let the lines EMN and BFZH be so drawn, that FZ = ZH, then $ED : DM = ED^3 : ZD^3$.

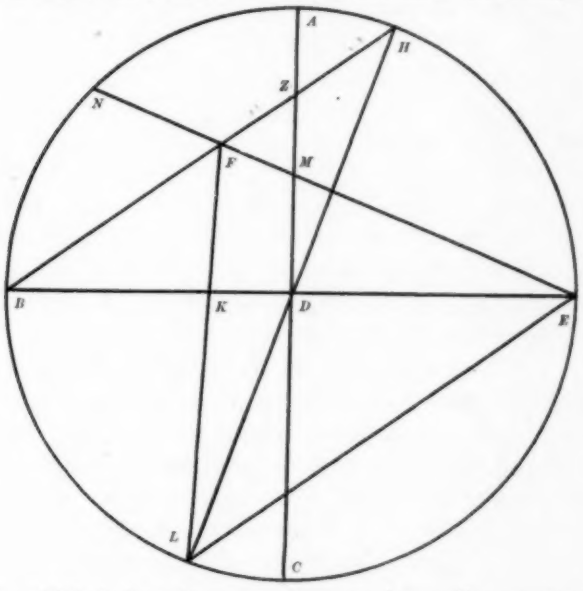
Let HD be drawn and produced to L a point of the circumference, and LF and LE be drawn, then FL is parallel to ADC and BH to LE. Now in the semicircle BLE, LK is perpendicular to the diameter BDE, and is therefore the mean proportional between the lines EK and KB. Therefore

$$EK^2 : KL^2 = EK : KB, \text{ that is,}$$
$$BD^2 : ZD^2 = DZ : DM.$$

Then multiplying both sides of the proportion by the ratio BD : ZD,

$$BD^3 : ZD^3 = BD : DM, \text{ that is,}$$
$$ED : DM = ED^3 : DZ^3.$$

The construction of an instrument for doing this is accomplished as follows. Let there be a plane round table, and in this let there be a circle ABC described, whose radius is less than the radius of the table, and through the center let the diameters BDE and ADC be drawn perpendicular to each other, and in a hole at B let a round peg be inserted, and on this a perforated rule BFZH be so fixed that it may move easily about the center B. Let a clamp be placed on the peg, so as to hold the rule as it



revolves, which being done, a cube may be easily constructed the multiple of any given cube. If we wish to make a cube double another, then we make DE = 2DM and draw the line EMN and then move the rule BFZH so that the portion between the line EN and the circumference is bisected in Z, the point of intersection with AD, so that FZ = ZH. Then the line DZ is the edge of a cube which is half of the cube with the edge ED, according to the proof above.

It may be of interest to note at this point that the curves that are used in the solution of one of the three problems have been applied to the solution of one of the others. The conchoid may be used to duplicate the cube or trisect the angle, the quadratrix may be used to trisect the angle or may be applied to the quadrature problem. Since this is true one is naturally led to think that there is some connection between the three problems. But what that connection is, is still an open question.

THE PRESENT STATUS AND REAL MEANING OF GENERAL SCIENCE.

By Fred. D. Barber,
Illinois State Normal University.

One characteristic marks off the nineteenth century from all preceding centuries in the world's history. That characteristic is the achievements of science and man's mastery over the forces of nature. The nineteenth century opened with such means of transportation and communication only as were enjoyed by Abraham when he journeyed out of Ur of the Chaldees unto the land of Caanan. Under such conditions man, perforce, through all the centuries of his existence had led an isolated life. Within one century, through the influence of the railroad and trolley line, the telegraph and telephone, the ocean cable and the ocean grayhound, the wireless and the newspaper, time and space were all but eliminated and the whole civilized world became a single social unit.

A second phase of the achievements of science was the recasting of all the activities of daily life. The achievements of science during the last century completely revolutionized the home, the school and its surroundings, every phase of country, town and city life, all methods of heating and lighting, ventilation and sanitation, of obtaining food and clothing, in fact they revolutionized all activities of daily life. To fit into this modern world anywhere, understandingly, some knowledge of the living world and the physical forces about us is a necessity. *The social significance of science in modern life gives it ever increasing importance as a subject in our public school curriculum.*

Again, the content of our knowledge concerning the natural world and physical forces is increasing with a rapidity and a certainty almost beyond the comprehension of the human mind. For convenience, the mature scientist, viewing this new world of knowledge philosophically, divides it into many so-called sciences and the mature student aspiring to do research work and make some contribution to our fund of knowledge necessarily confines his study to some small portion of a single science. Moreover, he can hope to succeed only by acquiring the technique of the specialist.

The great mass of humanity, however—those engaged in the world's work, laboring in the humbler walks of life, in production, as in agriculture, horticulture, gardening, stock raising or in min-

ing, or in the manufacturing industries, or in trade and commerce, or even in many of the professions—these people have slight need of such special training and technique. They need, instead, an insight into the broad general principles of science, and above all they need to see clearly and to comprehend the significance of science as it spins and weaves the social fabric of modern civilization.

Science Must Be Disseminated.

To neglect the training of research workers in the field of science would be fatal to further progress in man's control of Nature and her forces. It would mean stagnation in material progress and that must ever mean stagnation in mental, moral and spiritual progress. But, on the other hand, to neglect the interpretation and dissemination of scientific knowledge and the training of the masses of common people in scientific thinking is to rob humanity, in a large measure, of the fruits of scientific research. It is to the interest of all humanity that even the humblest laborer, toiling with pick and shovel, shall have some knowledge of the laws of science as related to his labor and his living. Modern civilization and all that is most significant to the common people in the way of improved living conditions, of more efficient labor, of shorter hours of labor and of greater facilities for recreation and pleasure depend largely and primarily upon, first, the achievements of the research worker in revealing the truths of science, and second, upon the dissemination of those truths among the common people and the training of the masses in thinking scientifically.

We are confronted today with no danger of neglecting the training of research workers in the field of science. Every great university in the land is chiefly engaged in this work. The ablest men in their science departments are spending their energies in training research workers in their graduate departments. The undergraduate departments of these universities, and most of our colleges, are largely engaged in preparing students to enter these graduate schools while the science courses in our high schools are in the main shaped and determined by college entrance requirements. Our high schools are vestibules to the college; our colleges are vestibules to the graduate school of the university. From top to bottom and from bottom to top the science work in our educational institutions is chiefly shaped and planned to furnish a direct path for the training of research workers. It is necessary that such a path be provided. But,

we must not lose sight of the fact that it is equally necessary that the needs of the masses of young people, preparing not for research work but for the ordinary activities of life, receive some consideration. Science falls far short of fulfilling its mission unless the fruits of scientific research fall upon fertile soil and take root in the daily life-activities of the masses.

Are our educational institutions preparing the masses to appreciate and utilize the products of research work in science? This can be done directly and efficiently only through science instruction in our public schools where the masses of young people should learn to interpret and to understand the significance of science as it affects their life work—to think scientifically as they work. And where are our great educational institutions which stand out conspicuously for their efforts and accomplishments in the training of science teachers for our public schools? Where are our great universities which emphasize the art of interpreting and disseminating the fruits of scientific research as they emphasize the art of research itself?

Decline of Science.

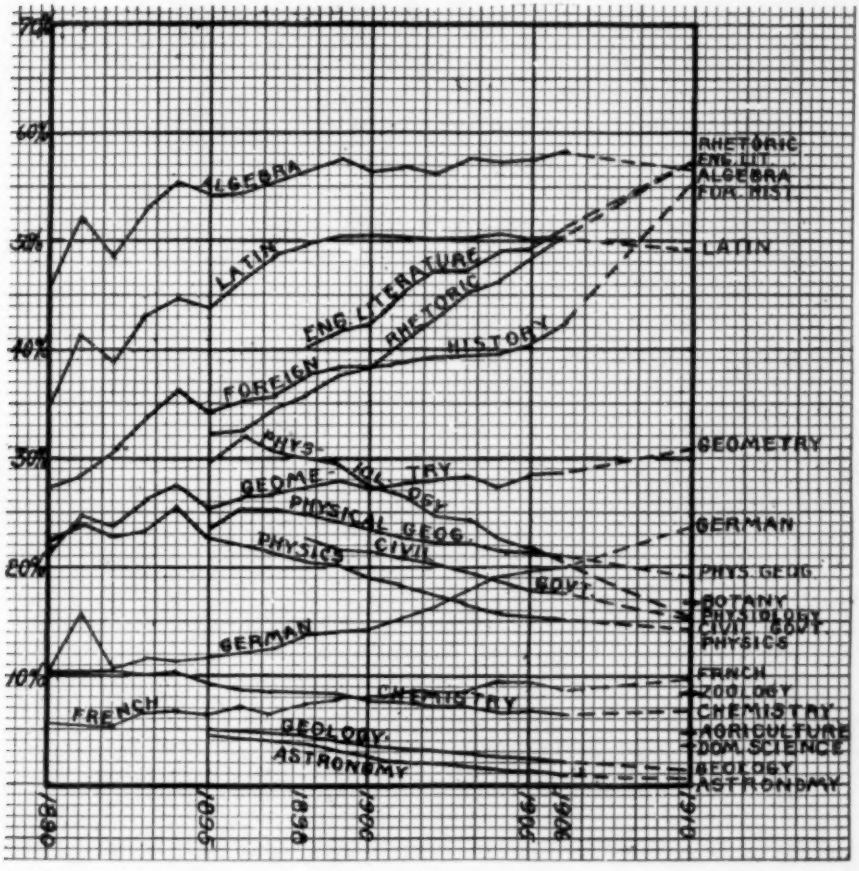
Notwithstanding the increased importance of science as a factor in modern life, it is a fact well known to students of education that the *percentage* of students studying the older sciences in our public schools is on the decline, and has been on the decline for twenty years. Leading educators have from time to time called attention to this fact. The Commissioner of Education has repeatedly shown it in his reports. And yet, the rank and file of public school superintendents, principals, and science teachers have until recently sat idly by, alternately boasting of the triumphs of science and lamenting the slowness of the farmer, of the laboring classes, in fact, of the masses everywhere, to avail themselves of the fruits of scientific research in their daily life-activities.

In commenting upon the tendencies in our high schools the Commissioner of Education in his report, 1911, reviewing the educational progress of the decade, says, "Latin is holding its ground; French and German are gaining; algebra occupies a large share of time and is steady; geometry is gaining; English and history have gained materially; all the older sciences, rather strangely, are relatively falling off."

At last we are waking up to the situation. We are beginning to realize that something is wrong—radically wrong—with our public school work in science. What is the trouble? Have you diagnosed the malady? Have you a remedy to suggest?

Over Specialization.

Some of us are convinced that the malady with which the public school science is suffering is directly traceable to an overdose of specialization. The needs of the research specialist are dominating and determining largely the college courses in science;



Graph, showing percentage of students studying each of the subjects in the public high schools of the United States during the twenty years from 1890 to 1910. From the report of the Commissioner of Education, 1910. Vol. 2, p. 1139.

college entrance requirements almost completely determine the character of our high school courses in science. We have built our science courses from the top downwards. We have attempted to start every fourteen-year-old boy and girl entering the high

school upon the path laid out for the benefit of the *exceptional* boy or girl who *may* become a research worker in the university. We have presumed that every fourteen-year-old youth is eager and ready to think in abstract terms. We have attempted to feed him on abstract principles and generalizations, never pausing to inquire about his likes and dislikes or to study the fundamental characteristics of the adolescent mind. We have failed to note that boys and girls of fourteen are chiefly interested in learnings things for the sake of knowing those particular things. The adolescent is not yet a philosopher. Abstractions, generalizations and type-studies are foreign and distasteful to the normal adolescent mind. Youth is ambitious, but it ever seeks the short cut. Necessity also plants its iron heel firmly down upon the ambition of the youth from the toiling classes. The wail and clamor from hungry mouths, the pleadings for the necessities of life are ever ringing in his ear, and in the ear of his parents. If he enters the high school at all it is generally for the purpose of spending one or two years, possibly three or four years, in better preparing himself for life's work—for the struggle of earning a living. The boys and girls from the laboring classes, indeed, from the masses of the common people everywhere, as well as their parents, have a right to demand that they be shown the worth-whileness of the tasks set before them. Can our high school principals and science teachers do this successfully while following the usual courses in special science shaped and planned for a different purpose?

The disregard of the nature and character of the adolescent mind together with the failure of the high school to offer subject matter which appeals to the boys and girls from the masses as being worth while largely accounts for the fact that only about 30 per cent of the boys and girls of high school age ever enter the high school and that 40 per cent of those who do enter quit the first year and only 28 per cent of them complete the course and graduate. Educators are beginning to realize these facts. The widespread conviction that our science courses in the high school must be revised is one of the results of this awakening. The experiment of putting so-called general science in the first high school year is part of this movement.

Present Status of General Science.

At the request of the chairman of the Science Section of the National Educational Association, I undertook last summer to discover the status of what is known as general science. I endeavored to ascertain where and in how many high schools courses

called general science were being taught and later to obtain from the principals of some of those schools information as to what they were attempting to do and with what measure of success their efforts were meeting. From my investigation I conclude that during the school year of 1913-14 not less than 250 or 300 schools in the United States attacked the problem of revising their science courses by offering a course which they called general science while large numbers of other schools seriously contemplated doing so soon.

About June 1, 1914, a questionnaire was sent to 180 schools reported as offering a course in general science. With few exceptions these were addressed to the principals. Up to June 25, replies from 73 schools had been received. No course called general science was reported from six schools. Replies from 67 schools indicate that they had seriously attempted work in general science as they understood the term. All the questions were framed with the idea of stimulating thought rather than obtaining ease of tabulation. Some of the replies were consequently rather difficult to tabulate, but it is the belief of the writer that a truer expression of ideas was obtained.

A complete analysis of this report is unnecessary. Facts, if correctly reported, are facts, and therefore undebatable. They are, nevertheless, of the greatest value since they furnish the only reliable basis for opinion. I shall call attention to but two items under the questions of fact. First, in replying to the second question, Length of course offered, but one school reports a course in general science more than one year in length. I predict with confidence that a similar investigation ten years hence, possibly five years hence, will reveal many schools offering such courses two years in length. Second, in reply to the question what text was used, eleven different texts were used in giving general science courses. To one at all familiar with the science texts available during the school year of 1913-14 the replies to this question together with the answers to the tenth question in the second list, indicate that up to that date at least no generally satisfactory texts had made their appearance. I am also convinced that for some years to come, at least until there is available a supply of teachers especially trained to teach general science, textbooks presenting well organized courses will be as necessary in general science as they are in special science or in any other subject offered in our high schools. The greatest need today, one felt keenly by every science teacher who has become convinced that our science teach-

ing has become too highly specialized, is for organized courses in general science. Furthermore, however true it may be that the best science teaching in the first high school year is merely the teaching of the science of the pupil's environment, it is asking the impossible when we ask each teacher to organize such material and put it in teachable and available form.

Passing to the questions of opinion: Opinions are always debatable but the answers to the first and second questions:

1. In your judgment, has the work in general science been a success? Answers: Yes, 47; Decidedly so, 13; Doubtful, 4; No, 1; Don't know, 2.
2. Has its degree of success been greater or less than might have been obtained from systematic, special science in the same grade taught by the same teacher? Answers: Yes, 49; Doubtful, 7; Don't know, 1; Not the question, 1; Answer later, 2.

indicate clearly, to my mind, that thus far the experiments with so-called general science have met the approval of the principals of the schools in which they have been tried. It was most interesting to me to discover that the only person answering the first question in the negative answered the second question in the affirmative.

In my judgment the most significant question in the entire set was the sixth in the second list: Should the units of instruction in general science differ materially from those in special science? And yet, there were fewer answers to this question than to any other. The term, "units of instruction" seems not to have been understood and still from the replies one is warranted in concluding that many of the respondents have no clearly formulated ideas regarding the real nature and real significance of the general science movement. Science organized and developed into units of instruction *not materially differing* from the units of instruction in special science can be nothing other than special science. To attempt to organize science material without recognizing the fundamental difference in the organization of special science and general science is certain to result, it seems to me, in a mere collection of loosely related principles picked from the various special sciences. Those principles may be the most interesting and striking principles of the special sciences and yet such a course might easily have considerably less significance as educative material than any course in special science. Apparently much of the so-called general science thus far taught is simply fragmentary special science and of very doubtful educational value.

(To be finished in April.)

SCIENCE TEACHING BY PROJECTS.[1]

By John F. Woodhull,
Columbia University.

There are those who say that nothing worthy to be called science may be taught before the last three years of the high school course —the Senior High School. They say that real, serious science is to be found chiefly in the college, and that what is permissible in the senior high school is the learning of "fundamental principles" preparatory to college science. There are, however, others, who say that children from 12 to 15 years of age come nearest of all persons to using the method of the great masters of science, and practice the most real research.

"The native and unspoiled attitude of childhood, marked by ardent curiosity, fertile imagination, and love of experimental inquiry, is near, very near, to the attitude of the scientific mind."[2]

Bacon said, "We must become as little children in order to enter the kingdom of science."

"At present, the notion is current that childhood is almost entirely unreflective—a period of mere sensory, motor and memory development, while adolescence suddenly brings the manifestation of thought and reason . . . But thinking itself remains just what it has been all the time . . . Only by making the most of the thought-factor, already active in the experience of childhood, is there any promise or warrant for the emergence of superior reflective power at adolescence or at any later period.[3] Elsewhere Dewey says, it is not our function to teach children to think—they think quite as much as we do. It may be our privilege to guide their thinking.

We are told that the high school-college-preparatory course in physics, for instance, with its 200 odd topics, is serious science, that it is highly specialized and that it is preparatory to still more serious science hereafter. My opinion is that it is a disjointed skeleton of falsely called "fundamental principles": that it is not science and does not prepare for science; that it is not specialized at all but is a hodgepodge of stuff never met by intelligent people in real life.

Dr. Coulter in his address on what the university expects of

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[1] Abstract of addresses delivered at the Annual Conference of High School Teachers, University of Illinois, November 20, 1914, and at the annual meeting of New York State Teachers' Association, Albany, November 24, 1914.

[2] Dr. John Dewey, "How We Think."

[3] Dr. John Dewey, "How We Think." P. 65.

the secondary schools said, "The average college preparation presents to the university the most narrow and unevenly trained material that can be imagined."[4]

And those who deal with graduate students say the same thing about the college work.

Since the defects in high school teaching are due chiefly to the fact that high school teachers are college products and are close imitators of college methods we must first deal with the colleges.

"An ever present question in an institution of the higher learning is how to interest officers of instruction in the subject of education. They are certain to be interested, each in his own particular branch of study, but too few of them are interested in education itself. The consequence is that the teaching of many very famous men is distinctly poor; sometimes it is even worse. This results in part from the breakdown of the general educational process into a variety of highly specialized activities, and in part from the carelessness of college teachers as to everything which affects a student's manners, speech, conduct and sense of proportion, provided only he gets hold of certain facts which the teacher desires to communicate.

"One mistake into which college teachers are most likely to fall is that of confusing the logical with the psychological order in the presentation of facts. The really good teacher knows that the logical order is the result of mature reflection and close analysis of a large body of related phenomena, and he knows too that this comes late in the history of intellectual development. He knows also that the psychological order—the true order for the teacher to follow—is the one which is fixed by the intrinsic interest and practical significance of the phenomena in question. The good teacher will not try to force the logical order of facts or phenomena upon the immature student. He will present these facts or phenomena to him in their psychological order and so give him the material with which to understand, when his knowledge is sufficiently complete, the logical order and all that it means. . . .

"It should be possible for an advanced student specializing in some other field to gain a general knowledge of physical problems and processes without becoming a physicist; or a general knowledge of chemical problems and processes without becoming a chemist; or a general knowledge of zoölogical problems and processes without becoming a zoölogist; or a general knowledge

[4] School Review, Vol. XVII, P. 81.

of mathematical problems and processes without becoming a mathematician. The reply that knowledge has become so highly specialized that no one can be found to give such courses of instruction is the saddest confession of incompetence and educational failure that can possibly be made. It ought not to be made except under cover of darkness."[5]

The process of learning in school should not differ from that out of school.

"Adults have some occupation about which their thinking is organized. Information is not amassed and left in a heap. Inferences are made not from purely speculative motives but because they bear upon some of life's problems."[6]

Dr. McMurry states the case convincingly as follows: "Should the student be a collector of facts at large, endeavoring to develop an interest in whatever is true, simply because it is true? Should he be unmindful of particular problems? or should his study be under the guidance of a specific purpose?"

"Much has been said in times past about art for art's sake, science for the sake of science, and knowledge for the sake of knowledge, but these are vague expressions that will excite little interest so long as the worth of a man is determined by what comes out of him, by the service he renders, rather than by what enters in."[7]

"There is nothing less profitable than scholarship for the mere sake of scholarship, nor anything more wearisome in the attainment. But the moment you have a definite aim, attention is quickened, the mother of memory, and all that you acquire groups and arranges itself in an order that is lucid, because everywhere and always it is in intelligent relation to a central object of constant and growing interest."[8]

"If students regularly occupy a portion of their study time in thinking out live questions that they hope to have answered by their further study, and interesting uses that they intend to make of their knowledge, they are equipping themselves with active power both for study and for the broader work of life."[9]

"Indeed the reason why self-trained men so often surpass men who are trained by others in the effectiveness and success of their reading, is that they know what they read and study, and have definite aims and wishes in all their dealings with books."[10]

[5] Annual Report, Nov., 1914, President Butler, Columbia University.
[6] "How We Think." P. 41.
[7] How to Study. Pp. 16 and 198.
[8] How to Study, p 37. . . . quoting Lowell.
[9] How to Study, p. 39.
[10] How to Study, p. 33, . . . quoting Porter.

Some are accusing General Science of lacking organization of subject matter. But when rightly understood it will be found that the whole movement is an attempt to introduce first of all a very specific organization where none now exists, and secondly a very different kind of organization from that hitherto attempted. This lack of organization which makes the school below a sort of dumping ground for the school above is one of our grievances. If the teacher above wants to use the slide rule, the teacher below must teach it. If he wants to use the metric system, the teacher below must teach that. If the college professor wants to measure gas as no one else on earth does it, the high school teacher must teach that process even though it crowds out a thousand more important matters judged from the standpoint of the pupil's needs. These pupils are going to buy and sell gas all their lives. But anything done in school to teach them to do that intelligently is decried by some as savoring of the practical.

Very little of this knowledge which the high school pupils spend so much time to acquire, is possessed by any intelligent group of persons. But for the high school pupils it ranks as "fundamental principles" preparatory to "serious science."

"The greatest problem that the schools are facing is the lack of intimate relationship between the work of the schools and the work of the world. School work needs to be real instead of artificial. When pupils are learning something real that has an object behind and a result to come, they are energetic, when they listen to or watch or read something that is to them artificial, they are apathetic. In all of these characteristics the children in our schools closely resemble us adults."

"The most serious defect of the present course of study, is that it makes thousands of children waste tens of thousands of precious hours in the laborious acquisition of facts for which they will never have any practical use. The material which the children in the schools are daily learning is of a sort that is seldom or never met with in the business of even the most successful men engaged in commercial and professional pursuits."[11]

Eleven prominent men of Springfield, Ill.—a state senator, a lieutenant governor, a banker, a physician, a lawyer, a clergyman, a merchant, the president of a manufacturing company, a superintendent of parks, an efficiency engineer and a newspaper editor—allowed themselves to be examined on the spelling, the geography, the arithmetic and the history taught to the fifth, sixth

[11] See Educational Survey of the Public Schools of Springfield, Ill., by Leonard P. Ayres, Ph. D., Division of Education, Russell Sage Foundation, New York City.

and seventh grade of the schools of that city. Not one of them could make a passing mark in any of these subjects, as taught to the little children of ten to twelve years of age. Does anyone think that these men, or any other group of intelligent citizens, would succeed any better with the so-called fundamental principles of high school science?

The movement for general science is first of all a protest against the present regime of unorganized subject matter. We propose *general* science as an antidote for that which now is too general to be called *science,* either serious or flippant. The movement for general science is in the second place, an attempt, for purposes of instruction, to introduce a "psychological organization," as Dr. Dewey puts it:[12] or a "genetic organization," as President Hall states the case:

"The chief among many reasons why all branches of science are so disappointing to their promoters in high school and college is, that in the exact logical, technical way they are taught, they violate the basal law of psychic growth, ignore the deep springs of natural interest and attempt to force a precocity against which the instincts of the young, so much wiser and truer and older than their consciousness, happily revolt."[13]

Organization of subject matter must be made around the knowledge of the pupil, not around that of the teacher or syllabus maker. We have to build on the instincts and experiences of the individual, otherwise we are hanging our building on a hypothetical foundation in mid-air.

The real way to learn fundamental principles is to attack those problems of which life is full for each individual, not through the preparatory fallacy called the scientific method, but by a "forked road situation." The school should prepare pupils to walk alone by attacking real problems as Archimedes, Galileo, Davy, Faraday, Pasteur, Tyndall and all the rest did. Most of us know, if we would think back over our experiences, that we never really learn these so-called fundamental principles until they come to us as an interpretation of some of our life's problems. Our teaching bears so little fruit because we are attempting what in the nature of the case can never succeed. We know that we are not learning things that way now, never have learned things that way, never can. We prescribe that sort of "serious science" for the defenceless, and when their unerring instincts revolt, we accuse them of being unwilling to be serious, unwilling to work, even while they

[12] See, "How We Think," Chap. V.
[13] "Adolescence," Vol. II, Chap. XII.

are pleading to be rid of us that they may get to work. It is not merely the geniuses like Newton, Maxwell, Kelvin and all the rest who thank the Lord when they get out from under their teachers, but this is likewise true of many of the pupils of today, some of whom instinctively know what science is, and are pursuing it in spite of us and outside of our tuition.

Imagine one of us in the following situation; we build a dam across a stream of water, and the pond that thus results surrounds some trees which we value. In our ignorance we may think the trees will fare better now than before, having an abundance of water and food brought to them by the river. But soon they die, and we go to the botanist, for light on this subject, and he undertakes to prescribe to us, as he does to his pupils, something like this: "You must take a series of preparatory courses in botany before I can help you with your problem. Here is a First Course in Botany for children which I prescribe." It has 158 pages, the first thirty-six of which classify leaves as net veined, parallel veined, feather veined, palmate veined, entire, serrate, crenate, dentate, repand, hastate, sagittate, lanceolate, cordate, ovate, reniform, orbicular, rotundate, acicular, deltoid, spatulate, peltate, runcinate, pedate, lyrate, pinnate, digitate, cirrus, adnate, ochreate, sessile, etc. for thirty-six pages. You are advised to have the leaves present to make the study concrete. This is classified knowledge, and hence science, serious science, preparatory serious science. As a supplementary exercise one might classify all the nails in the school yard fence.

Or imagine ourselves going to a physicist for information regarding a self-starting system for our automobile, and his prescribing Newton's laws of motion, Boyle's law, Charles' law, Lenz's law, Archimedes' principle, index of refraction, laws of falling bodies, law of reflection, law of cooling, Ohm's law, polarization in a cell, specific heat, modulus of elasticity, hysteresis, etc., up to 260 items of unclassified knowledge which the physicist is so lacking in a sense of humor as to call *serious* science.

This is the preparatory fallacy and it runs throughout all our subjects. Our method of teaching science today by the study of "fundamental principles" is closely analogous to what was in vogue about a century ago in the field of grammar, when children were required to commit to memory rules of grammar, to learn syntactical laws of language and acquire skill in logical analysis in order that they might be prepared to read, write and speak. The analogy goes still further. We have recently heard some-

thing of an attempt to make physics a little more concrete by the interjection here and there of a few applications of principles for the sake of elucidating these "fundamentals." It was about 1823 that the teaching of rules of grammar was made a trifle more concrete by the introduction of sentences to which the rules might be applied. For a discussion of this sort of teaching grammar see Dr. Brigg's monograph in Teachers College Record, Vol. XIV, from which it appears that science teachers today are in perfect accord with English teachers of a century ago in attempting to present an adult, scholarly interest to children by a logical and metaphysical treatment of their subjects. "Tradition has perpetuated details which have lost much or all of their justification. When old reasons have faded there is a tendency to invent new ones to justify practice."

This attempt to store facts for future organization is what the Massachusetts Board of Education in Bulletin 4, 1912, calls "Education in Forgetting." "The structure and habits of the human mind and brain are such that following the psychological laws of segmentation, unused knowledge tends to be forgotten. Much, a vast deal, of the subject-matter turned over and otherwise dealt with by the subject-study method is of such a nature that in out-of-school hours and in after-school years it remains unused. Examinations once passed and the school year ended, subjects are forgotten. . . . But project study has merits peculiarly its own. No more diligent or effective application of the inductive method in education has ever been witnessed than that proposed, and in good measure already practiced, by the project study of agriculture."

"The knowledge which is the boy's quest in project study is knowledge of which he sees the need. Being needed year by year, it will, year by year, be recalled. Used again and again, added to, modified and exactly applied, it will tend to be distinctly remembered."

"The project method of education, more, it is believed, than all others, takes into account the aptitudes, requirements and accomplishments of individual pupils as these are revealed from hour to hour."

The Smith-Lever bill which has just passed Congress appropriates five million dollars annually to foster the *project method of study* in agriculture throughout the country.

The project method in *General Science* is more specialized than any portion of the college preparatory science, and like a dog pursuing a hare, it has a specific aim, albeit it jumps

those useless boundary fences between the various fields of science. This is our justification for the use of the word *general*.

The idea of completeness—complete statements of facts and principles, is one of the greatest barriers to successful teaching. The attempt to teach all that is known about each topic results in very little being understood about any topic. What is wanted is to set the face in the right direction; teach the first steps; arrange many facts and many observations to point in a similar direction; acquire the habit of having one experience suggest another.

The method is precisely that of the masters of research who are, after all, *Masters of General Science*. There is no difference between educating for research and educating for life. But the high schools and colleges have a strong propensity to neglect this, their chief duty. It requires continual belaboring to get the high schools to do much else than to cram facts for college use. The colleges do little else for education than to prepare professors' assistants; professors' assistants in research, professors' assistants in college teaching, professors' assistants in high school preparation for college.

One hundred and fifty years ago the academies were founded as a protest against the idea which dominated the grammar schools of the time that education consisted in storing the facts which the higher institutions would use. These academies were called the people's colleges. The pupils were to be taught wholly according to their own needs. But forthwith the process of inbreeding began. The teachers appointed for these academies were youths recently graduated from college; in effect professors' assistants who stored data for college use, a process as futile to the education of the few who went to college as to the many who did not. Again the same protest was renewed fifty years ago in the founding of public high schools. These were to be free from the preparatory fallacy to which the academies had fallen victims.

It remains to be seen whether the high schools, which are the people's colleges of today, can be saved from repeating this history. During the last twenty years we have had committees of ten, of fifteen, of seven and of various other numbers laboring to saddle the preparatory job upon the under school. Perhaps the thing most to be feared is that the colleges may accept General Science and place it in the preparatory group. Before this happens we must introduce into the school and college the psychological organization of instruction and suppress the preparatory fallacy.

INTERESTING TECHNICAL POINTS ON GEMS.[1]

By Frank B. Wade,
Shortridge High School, Indianapolis, Ind.

In a recent issue of The Jewelers' Circular M. D. Rothschild, in an article entitled "A Few Words on Precious Stones," said: "Apart from diamonds, however, knowledge of precious and so-called semi-precious stones and pearls is lamentably lacking among many of the retail jewelers of this country." It was evidently in the attempt to overcome some such lack among the jewelers of the United Kingdom that the National Association of Goldsmiths began last year giving annual examinations in gemmology. The examinations are divided into preliminary and diploma examinations, the latter having a practical test attached, as well as the written test, and being in general of a more advanced type.

With a view to helping spread abroad among the jewelers of this country a wider knowledge of the scientific side of gem-lore the writer has undertaken to discuss briefly a number of the questions asked this year in the National Association of Goldsmiths' examinations.

The first question of the preliminary examination set (which was also the first of the diploma set of questions) asks:

1. *To what mineral species do the following stones belong: Cairmgorm, carbuncle, jargoon, peridot, rubellite? What do jewelers understand by "Cape-ruby," "carbon," "green garnet," "topaz?"*

Answer: By "mineral species" is understood a single substance having (except for mechanically admixed impurities) practically a constant chemical composition and having practically identical physical properties in all specimens of it. Thus "corundum" is a "mineral species," being the chemical substance "oxide of aluminum" in a nearly pure condition. Corundum has many varieties—the ruby being red corundum, the sapphire blue corundum, the "Oriental topaz" yellow corundum, etc. In spite of the marked differences of color, these stones are in all other respects practically identical—having the hardness nine on Moh's scale,

[1] The following articles are part of a series of papers on precious stones published in the *Jewelers' Circular* of New York during the past summer. They were intended to help instruct the retail jewelers of the country in the scientific side of gem lore. As many of the articles deal with applications of physics or chemistry or elementary mathematics, it was thought possible that selected articles might prove of interest to teachers of these subjects and perhaps also to pupils in their classes.—F. B. W.

being very nearly four times as heavy as the same bulk of water (specific gravity equals four), etc. Thus they are all of the same mineral species.

Having illustrated what is meant by the term, let us next apply it to the cases in question.

The cairngorm (so named, it is said, from the Cairngorm mountains in Scotland), is the brownish variety of the mineral species *quartz,* to which species the amethyst, the common "topaz," so-called, and many other semi-precious stones belong. Like them all, it has the hardness seven on Moh's scale, scratching feldspar, but being scratched by true topaz ("precious topaz").

The term "carbuncle" has by usage come to mean a crimson *garnet* when cabochon cut. The term is derived from the Latin carbunculus, a coal, referring to the glowing red light of the stone. It formerly meant almost any deep red stone. Either the pyrope (fire) garnet or a crimson almandine garnet might properly be called a carbuncle when cabochon cut. The mineral species then is one of the *garnets* (of which there are many varieties). In hardness the red garnets run from about 7 to 7½ on Moh's scale, the variety pyrope being slightly harder than quartz and the almandine slightly harder than pyrope.

The "jargoon" is the white to grayish or smoky variety of the mineral species *zircon.* Jargoons almost always owe their lack of color to a heat treatment. They have a hardness of about 7½, scratching quartz, and they possess adamantine luster to a marked degree, in that respect resembling the diamond. The high density of these stones (specific gravity 4.7 nearly) carries with it a high refractive index (this term will be defined in the next article) and a high dispersion (on which property the play of rainbow colors depends). Hence, a well cut jargoon has sufficient brilliancy and "fire" to easily pass for a diamond on casual inspection even with one who is more or less accustomed to judging precious stones.

The "peridot" belongs to the mineral species known as *"olivine."* This must not be confused with the "olivine" of the trade which is usually the green garnet (demantoid garnet) of the Ural mountains. Olivine, the mineral, is softer than quartz and suitable for wear only in articles which are not subject to hard usage. The peridot is a bottle green variety of this mineral.

Rubellite is reddish or pink *"tourmaline,"* a mineral slightly harder than quartz, but very brittle. Answering the second part

of the question, jewelers mean by "Cape ruby" the crimson garnet of the diamond mines of South Africa, which is a pyrope garnet.

By "carbon" is probably meant in this connection the "carbonado" or black opaque minutely crystalline variety of diamond which is found in Brazil and which is used for rock drilling at great depths, where its great toughness, as well as hardness, makes it better suited to the purpose than the more brittle "bort."

"Green garnet" has already been referred to in connection with the unfortunate confusion in use of the name "olivine." It is the demantoid (literally diamond-like) garnet of the Ural Mountains. It is rather soft, 6½ on Moh's scale, but possesses a splendid diamond-like luster and high refractive index and a dispersion that even exceeds that of diamond, so that it is very fiery.

By "topaz" the jeweler usually understands yellow quartz, rather than the true topaz (mineral species topaz), which is a heavier (3.53 instead of 2.66 in specific gravity) mineral and also a harder one. The true or precious topaz is not often seen in a jeweler's stock nowadays. The "Oriental topaz" is, as was suggested in the first part of this article, the yellow corundum.

PART II.

Question 2. *Define refractive index, double refraction, "fire," dichroism. Give lists of gem stones possessing single refraction or marked dichroism.*

ANSWER: Before attempting to define "refractive index" it will perhaps be well to briefly consider what is meant by refraction of light. Literally, of course, the term refraction means "to break"—"again." Technically, the term refers to the breaking of the path of light on entering a rarer or a denser transparent substance than the one in which the light was previously traveling. Everyone is familiar with the fact that a straight stick appears bent when partly thrust under water at an angle other than a right angle with the surface.

As the stick is straight, it must be the light reflected from the stick through the water and then through the air to the eye that bends as it leaves the surface of the water. This is a case of refraction of light. The study of this phenomenon in its many cases shows that the amount of bending depends upon the particular substances concerned and also upon the relation of the direction in which the light is traveling to the surfaces of the two substances. Thus diamond bends light which enters it from

the air much more sharply than white sapphire. Also light entering either of these substances from the air will be bent more sharply if it enters at an oblique angle than if it enters nearly perpendicularly. When passing in a perfectly perpendicular direction from one substance to another no bending of light takes place.

It has been found further that for a particular substance, say, diamond, the amount of bending of light entering from the air always bears a fixed mathematical relation to the angle between the line made by the beam of light and a line drawn perpendicularly to the surface of the stone at the point where the light enters it. It was in the attempt to give a numerical value to this effect in the case of every transparent substance that the mathematical device called the "refractive index" was adopted.

The refractive index of any substance is briefly defined as *the ratio of the sines of the angles of incidence and of refraction.*

In the case of diamond, which bends light more sharply than any other common gem, the value is of the refractive index about $2\frac{1}{2}$. The practical jeweler may not need to know the mathematics of this subject (although it would be no disadvantage to him), but the practical bearing of refractive indices to the brilliancy of stones is of considerable importance.

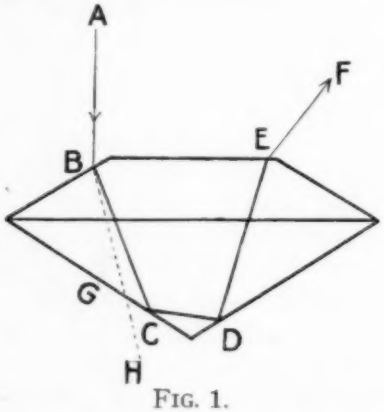


FIG. 1.

For instance, see Fig. 1, representing a spread cut diamond. A B represents the path of a beam of light coming toward the stone from in front. It is *refracted* at B, taking a new path B C. At C it is totally reflected (just as though there were foil on the back, but none is necessary in this case, because diamond totally reflects light that strikes its interior surfaces at angles greater

than about 24° to the perpendicular at the point of contact). Passing along C D the light is again totally reflected at D (in each of these reflections it is true that the angle of incidence equals that of *reflection*) and at E the light emerges into the air (this time crossing and bending (being refracted) away from the perpendicular to the surface at that point) and proceeds along E F to dazzle the beholder.

Had the material not been diamond, with its high refractive power, the beam of light A B (to again refer to Fig. 1) would have taken some other course, say, B G, and would have struck the back facets of the stone too nearly perpendicularly to be totally reflected, and it would have pierced the surface (unless foil were used) and have been lost behind the stone along G H. Hence a spread cut brilliant of any material with a low refractive index is lacking in brilliancy. Even with diamond if the spread is too great the light fails to be totally reflected from the back facets, especially in the center, and a "fish eye" results; that is, the center is weak.

It is possible to determine mathematically just what shape any given material should have to produce the maximum possible brilliancy. I have worked out such a calculation and find that practical lapidaries, and especially diamond cutters, have arrived at very nearly the correct angles, in their best products, probably by the world-old method of "trial and error" and then a retrial until, by passing on improvements from one generation to another, results have been attained approximating those which theory calls for.

PART III.

QUESTION 2 *(Continued): Define double refraction.*

Answer: In the previous article defining "refractive index" the meaning of refraction was explained. It was shown to mean the bending or change in direction of a beam of light on passing from a rarer to a denser medium, or vice versa. The jeweler, it was pointed out, is interested mainly in the passage of light from air to a denser material (a gem stone) and its return to the air again after total reflection within the stone.

Now, while the fact was not mentioned in the previous article, lest too much be attempted at once, it is a fact that many transparent substances cause a *splitting* or *separation* of a beam of light that enters them from without. The light now follows two separate paths within the stone and on emerging comes out at two different points on the surface.

The mineral which gives most marked *double refraction* (as it is called) of all common minerals is calcite, perhaps better known in finely crystallized masses as Iceland spar. . On looking at a single ruled line on paper through a crystal of this mineral two lines are apparently seen if the crystal is held in proper position. Iceland spar, like other doubly refracting minerals, has one direction (some minerals have two) in which it is only singly refracting.

Few gem stones separate light as widely as does Iceland spar. Nevertheless peridot (bottle green olivine) separates the light widely enough so that with an ordinary lens one can easily see an apparent doubling of the lines made by the edges of the back facets when one looks into the stone through the table facet. Zircon also shows this phenomenon markedly, so much so that perhaps the easiest test to use to detect that a finely cut colorless zircon (jargoon) is not a diamond is to note its double refraction in the above mentioned way, or, better yet, to reflect direct sunlight from inside the stone onto a white card, when *double* images of the facets (colored spectra) will appear on the card, whereas diamond, being singly refracting, will give a cluster of solitary images.

QUESTION 2.—*"Define 'fire.'"*

ANSWER.—The term "fire" as used in connection with precious stones has reference to the play of rainbow colors, which is seen at its best in the diamond, especially when the stone is pure white in its substance.

The effect is to be seen, but to a less degree, in colorless zircon, in sphene (titanite) and in the demantoid (diamond like) garnet of the Urals (commonly sold under the trade name of "olivine").

Colorless stones other than the diamond and zircon show very little "fire," and hence lack much of the attractiveness that the diamond possesses.

The play of colors shown by the opal is of a different nature from the "fire" of the diamond, and should be called opalescence rather than "fire" to avoid confusing the two phenomena.

A brief explanation of the cause of "fire" in a gem may not be out of place at this point. It depends upon refraction (an explanation of which appeared in the issue of July 22).

In that article we saw that light, on entering a transparent substance from the air, was bent or refracted, and that it took a new course within the substance. To avoid attempting too much at one time it was not explained that light of different colors

bends differently; that is, each color has its own refractive index. (According to the generally accepted theory, light consists of a wave-like vibration in what physicists call the "ether" which is thought to fill all space, and difference of color in light is supposed to be due to difference of wave length.) At any rate, violet light is bent more than red on entering a dense transparent material from the air.

Now, the white light of the sun consists of light of many different colors (or wave lengths), as anyone is aware who has seen the effect produced when sunlight falls upon a prism of glass such as our grandmothers used to have hung under their chandeliers. Rainbow colors, red, orange, yellow, green, blue and violet result.

Now for the relation of all this to the cut stone. A brilliant cut stone is also a prism. In Fig. 2, which represents the usual brilliant, a beam of white light, A B, is represented as entering the stone through the table at B. The violet light bends more than the red, and arrives at D, whereas the red arrives at C, the other colors lying between.

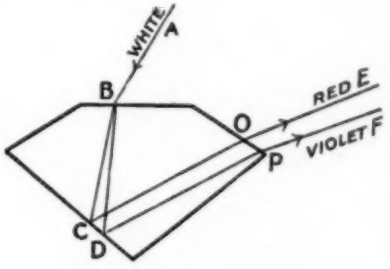


FIG. 2.

Now comes a slight difference from our first case. If the stone was properly cut the light that strikes its back surface, instead of emerging as it did from the prism, will be totally reflected, the red along C O and the violet along D P (Fig. 2), separating more and more widely the farther the beams travel in the stone until, on striking the bezil facets, the beams of light emerge, the red along O E, the violet along P F. An eye at E would be delighted by a flash of purest spectrum red, while one at F would receive a beam of electric violet hue.

(To be continued.)

RATE PROBLEMS.

By Lyman M. Saxton,
City College, New York City.

The following are typical of certain kinds of problems which ordinarily cause high-school pupils more trouble than almost any other kind:

1. The rate of an express train is $\frac{5}{8}$ that of a slow train, and it travels 36 miles in 32 minutes less time than the slow train does. Find the rate of each in miles and hours.

2. A and E can do a piece of work in 9 hours. After working together 7 hours, B finishes the work in 5 hours. In how many hours could each alone do the work?

3. A man bought a certain number of eggs. If he had bought 56 more for the same money, they would have cost a cent apiece less; if 24 less, a cent apiece more. How many eggs did he buy and at what price each?

4. A crew can row 10 miles in 50 minutes down stream and 12 miles in an hour and a half against the stream. Find the rate in miles an hour of the current, and of the crew in still water.

5. The fore wheel of a carriage makes 8 revolutions more than the hind wheel in going 180 feet; but, if the circumference of the fore wheel were $\frac{4}{5}$ as great and of the hind wheel $\frac{6}{7}$ as great, the fore wheel would make only 5 revolutions more than the hind wheel in going the same distance. Find circumference of each wheel.

6. A sum of money at 6 per cent interest, amounts to \$5,900 for a certain time and to \$7,100 for a time longer by 4 years. Find the principal and the time.

7. A party at a tavern found, on paying their bill, that had there been 4 more each would have paid 75 cents less; but if there had been 4 fewer, each would have paid \$1.50 more. How many were there, and how much did each pay?

8. A tank can be filled by one pipe in 9 hours and emptied by another in 21 hours. In what time will the tank be filled if both pipes be opened?

9. A laborer was engaged for 32 days on condition that for every day he worked he should receive \$1.75 and for every day he was idle he should forfeit \$1.00. At the end of the time he received \$28.50. How many days did he work and how many days was he idle?

10. The telegraph poles along a certain railway are at equal intervals. If there had been two more in each mile, the intervals between the poles would have been decreased by 20 feet. Find the number of poles in a mile.

11. If sound travels 1100 feet per second, how far away is a gun when the report of firing is heard $3\frac{1}{2}$ seconds after it occurred?

12. Two school track teams held a dual meet. One team scored 26 points, winning 7 first places and 5 second places; the other team scored 21 points, winning 6 first places and 3 second places. How many points did each place count?

13. A man hires a piano at \$5 a month of 30 days, and is to pay pro rata for any part of a month. What should he pay if he keeps the piano 51 days?

Problems like the foregoing are usually considered separately without attention being called to the fact that they all contain three

elements which are practically the same, although ordinarily called by different names in the different problems.

The equations giving the relation between the three elements are as follows, the numbers corresponding to those of the previously given problems:

1. Distance = rate×time.
2. Total amount of work = rate of work×time.
   (Represented by unity.)
3. Total cost = price for one object×number of objects.
4. Distance = rate×time.
   (Compound rate.)
5. Distance = Circumference × number of revolutions.
6. Total interest = rate×principal.
7. Total cost = cost per person×number persons.
8. Full tank = rate at which pipe emptied water×time.
   (Unity.)
9. Total wages = wage per day×number of days.
10. Distance = length of one interval×number of intervals.
11. Distance = rate of travel×time.
12. Total number of points = number of points for a place × number of such places.
13. Total charge = rent for one day×number of days.

All of these, however, are only special cases and are all covered by the general rate equation,

$R = rt$,

in which,

R = Total result of process, operation, work, transaction, or whatever action of any kind is referred to in the problem.

r = rate at which the action, process, and so on, takes place (the rate must be uniform).

t = number of times the rate is employed.

In all of the problems mentioned and all others similar to them, t is greater than one.

However the same relation exists when $t = 1$, although problems of this nature do not usually involve much difficulty for the student. For example. The cost of a house and lot was \$6,500; the house cost \$3,500 more than the lot. What was the cost of each?

The writer has found by experience that high-school pupils are much interested in noting the similarity between these various kinds of problems, and in picking out problems of this nature (rate problems) from any list of miscellaneous problems. With a little practice under the direction and encouragement of the teacher, many pupils readily acquire considerable facility in adopting the general equation and general methods of solution to the particular conditions and requirements of any specific problem. Other-

wise all of these different problems are worked out separately, a solution of one of them being of comparatively little assistance in the attempt to solve one of another kind.

General Methods of Solution.

I. One unknown used.

1. Let unknown quantity represent one of the three component elements.
2. Use one of the given conditions of the problem in order to obtain an expression for a second one of the three elements.
3. Use the remaining data of the problem to form the desired equation.

Note. The information obtainable from the problem may be given either explicitly or implicitly. The equation $R = rt$ must frequently be used as an aid in forming expressions and equation.

Example, one unknown quantity. A man has 11 hours at his disposal. How far can he ride in a coach which travels $4\frac{1}{2}$ miles an hour so as to return in time, walking back at the rate of $3\frac{3}{4}$ miles an hour?

Three elements $\begin{cases}\text{time}\\ \text{rate}\\ \text{distance}\end{cases}$

Let x = distance.

$$\left.\begin{aligned}\frac{x}{4\frac{1}{2}} &= \text{time going}\\ \frac{x}{3\frac{3}{4}} &= \text{time returning}\end{aligned}\right\}\text{using the equation } R = rt.$$

$$\frac{x}{4\frac{1}{2}} + \frac{x}{3\frac{3}{4}} = 11.$$

II. Two unknowns used. (In this case each of the three general elements will occur twice.)

1. Let x and y represent the two magnitudes corresponding to one of the three elements.
2. Use data given by the problem to form expressions corresponding to a second one of the three elements.
3. Use the remaining data of the problem for forming the equations.

Note: See note under I.

Example, two unknown quantities: A and B run a race of 450 feet. The first heat, A gives B a start of 135 feet and is beaten by 4 seconds; the second heat, A gives B a start of 30 feet

and beats him by 3 seconds. How many feet can each run in a second?

Three elements $\begin{cases}\text{time}\\ \text{rate}\\ \text{distance}\end{cases}$

Let x = A's rate of running.
y = B's rate of running.

First heat $\left\{\begin{array}{l}\frac{450}{x} = \text{A's time}\\ \frac{315}{y} = \text{B's time}\\ \frac{450}{x} - \frac{315}{y} = 4.\end{array}\right\}$ use equation $R = rt$ and given data.

Second heat $\left\{\begin{array}{l}\frac{450}{x} = \text{A's time}\\ \frac{420}{y} = \text{B's time}\\ \frac{420}{y} - \frac{450}{x} = 3.\end{array}\right\}$ equation $R = rt$, and given data.

Problems of this kind can also frequently be solved by using only one unknown quantity. Thus problem 9 on page 241.

Let x = number working days.

use $R = rt$ and given data $\begin{cases}32-x = \text{number of idle days.}\\ 175x = \text{number of cents received for work.}\\ 100(32-x) = \text{number cents forfeited.}\end{cases}$

$$175x-100(32-x) = 2850.$$

It is not sufficient just simply to call the attention of pupils to the analogy existing between the various types of rate problems. The teacher must first see that every pupil comprehends the meaning of "rate" and "rate problem." Then the "general rate equation" should be introduced and applied to various problems, in every case definitely noting that the three particular elements in any given problem are only special forms of the three general elements in the "general formula." The teacher should require every pupil to practice picking out rate problems from miscellaneous lists, in each case mentioning the three particular component elements involved and specifying which one of the three general elements each one of them corresponds to. The solution should then be developed on the basis of the "general formula" and "general methods of solution." If this procedure be *insisted* upon by the

teacher for a time, until the pupils have become thoroughly familiar with it and habituated to it, I venture to predict that both teacher and pupils will be agreeably surprised at the facility with which such problems will be solved ever afterwards.

TWO USEFUL THEOREMS IN GEOMETRY.

By Albert Babbitt.

Theorem I. *The product of the two arms of a right-angled triangle is equal to the product of half of its perimeter by the difference between the sum of the two arms and the hypotenuse.*

Given the right-angled triangle ABC, whose arms are a and b, and the hypotenuse is c. Let $p \equiv \frac{1}{2}(a+b+c)$.

To prove that $ab = p(a+b-c)$.

Proof
$$p(a+b-c) = \frac{(a+b+c)}{2}(a+b-c),$$
$$= \frac{(a+b)^2-c^2}{2},$$
$$= \frac{a^2+b^2+2ab-c^2}{2}.$$

Since ABC is a right-angled triangle,
$$a^2+b^2 = c^2.$$

Hence, $p(a+b-c) = ab$, or $ab = p(a+b-c)$.

Theorem II. *The square root of the area of the middle section of a frustum of a quadrangular pyramid is equal to half of the sum of the square roots of the areas of the upper and lower bases of the given frustum.*

Let B and b denote respectively the area of the lower and upper bases of the given frustum ABCD-A′B′C′D′, and let M denote the area of the middle section A″B″C″D″. Also denote the diagonals AD, A′D′, and A″D″ respectively by l, k, and m.

To prove that $\sqrt{M} = \frac{1}{2}(\sqrt{B}+\sqrt{b})$.

Proof: A″D″, being the median of the trapezoid ADA′D′, is equal to half of the sum of the bases, i. e.
$$m = \tfrac{1}{2}(k+l).$$

Hence, $k+l = 2m.$

Now, it is known that
$$\frac{B}{b} = \frac{l^2}{k^2},$$
$$\frac{b}{M} = \frac{k^2}{m^2},$$
(taking positive value of square root only).

Whence,
$$\frac{\sqrt{B}}{\sqrt{b}} = \frac{l}{k}$$
$$\frac{\sqrt{b}}{\sqrt{M}} = \frac{k}{m}.$$

From the theory of proportion, it follows that
$$\frac{\sqrt{B}+\sqrt{b}}{\sqrt{b}} = \frac{l+k}{k}.$$

Multiplying this relation member by member by the relation

$$\frac{\sqrt{b}}{\sqrt{M}} = \frac{k}{m},$$

we get $$\frac{\sqrt{B}+\sqrt{b}}{\sqrt{M}} = \frac{l+k}{m}.$$

Since $$l+k = 2m,$$

$$\frac{\sqrt{B}+\sqrt{b}}{\sqrt{M}} = 2.$$

Therefore, $$\sqrt{M} = \tfrac{1}{2}(\sqrt{B}+\sqrt{b}).$$

NOTE: This theorem evidently holds true for a tetrahedron.

TO FIND APPROXIMATE SQUARE ROOTS.

BY NORMAN ANNING,
Public School, Clayburn, B. C.

This method cannot, like the rules recently published in SCHOOL SCIENCE AND MATHEMATICS for squaring numbers, lay claim to the word "mentally"; but for speed it will compare favorably with the method ordinarily taught. As regards accuracy an error in any step is corrected by those that follow.

Let $n = ab$ and suppose $a<b$.

It is not hard to prove that when a and b are nearly equal, more exactly when $a<b<9a$, the arithmetic mean, $\frac{a+b}{2}$, is nearer to $\sqrt{n}$ than is either a or b.

To find $\sqrt{n}$ find a and b, two factors of n, which are as nearly equal as possible, then find arithmetic means successively of

$$a \text{ and } b,$$

$$\frac{a+b}{2} \text{ and } n \Big/ \frac{a+b}{2} \text{ and so on.}$$

This process shuts $\sqrt{n}$ in a region which becomes narrower at each step. The nearer b/a is to unity the more rapid the approximation.

Examples.

(1) $\sqrt{20}$. $20 = 4\times 5$, $\frac{4+5}{2} = 4\cdot 5$,

$= 4\cdot 5\times 4\cdot 444$, $\frac{4\cdot 5+4\cdot 444}{2} = 4\cdot 472$,

$= \sqrt{20}$ to three places.

(2) $\sqrt{38}$. $38 = 6\times 6\tfrac{1}{3}$,

$= 6\tfrac{1}{6}\times 6\tfrac{6}{37}$, $\frac{6\cdot 1667+6\cdot 1622}{2} = 6\cdot 1644$,

$= \sqrt{38}$ to four places.

(3) $\sqrt{1+2x}$ (x small).

$1+2x = 1\times(1+2x)$. $\frac{1+1+2x}{2} = 1+x$.

$1+2x = (1+x)\times\frac{1+2x}{1+x}$.

$= (1+x)\times(1+x-x^2+\ldots)$, $\tfrac{1}{2}(1+x+1+x-x^2)$

$= 1+x-\frac{x^2}{2}$.

(4) $\sqrt{2}$. $2 = 1\times 2,$
$= \frac{3}{2}\times\frac{4}{3},$
$= \frac{17}{12}\times\frac{24}{17}.$ $\frac{1}{2}(\frac{17}{12}+\frac{24}{17}) = \frac{577}{408} = 1\cdot 414215\ldots$
$= \sqrt{2}$ to five places.

The fraction $\frac{577}{408}$ is the eighth convergent of the continued fraction

$$1+\frac{1}{2+}\,\frac{1}{2+}\,\frac{1}{2+}\ \ldots$$

A PROBLEM IN ELIMINATION.[1]

By Albert Babbitt.

The elimination of x from two equations (in elementary mathematics) consists in finding a relation between the coefficients of the given equations which must hold if the two equations are consistent, that is if they are both satisfied by a common value of x. In order that the elimination be possible it is necessary that the number of equations *exceed* the number of the unknowns entering into the equations, i. e., in order to eliminate one unknown there must be given at least two equations; for the elimination of two unknowns at least three equations must be given.

We have given the two trigonometric equations

$$\frac{\cos(a-3x)}{\cos^3 x} = \frac{\sin(a-3x)}{\sin^3 x} = b.$$

And let it be required to eliminate x.

The given equations may be written thus:

$$\cos(a-3x) = b\cos^3 x. \tag{1}$$

$$\sin(a-3x) = b\sin^3 x. \tag{2}$$

However, since $\cos^3 x = \frac{\cos 3x+3\cos x}{4}$, and

$$\sin^3 x = \frac{3\sin x-\sin 3x}{4}$$

(1) and (2) can be rewritten as follows:

$$\cos(a-3x) = \frac{b}{4}(\cos 3x+3\cos x). \tag{3}$$

$$\sin(a-3x) = \frac{b}{4}(3\sin x-\sin 3x). \tag{4}$$

Squaring and adding (3) and (4) we have

$$\frac{b^2}{16}[1+9+6(\cos 3x\cos x-\sin 3x\sin x)] = 1, \text{ or}$$

$$b^2(10+6\cos 4x) = 16. \tag{5}$$

Now, multiplying through (3) by $\cos 3x$, and (4) by $\sin 3x$, we obtain,

$$\cos 3x\cos(a-3x) = \frac{b}{4}(\cos^2 3x+3\cos x\cos 3x) \tag{6}$$

$$\sin 3x\sin(a-3x) = \frac{b}{4}(3\sin x\sin 3x-\sin^2 3x) \tag{7}$$

Subtracting (7) from (6),

$$\cos 3x\cos(a-3x)-\sin 3x\sin(a-3x) = \frac{b}{4}[1+3(\cos x\cos 3x-\sin x\sin 3x)],$$

[1] This problem has quite a history. It was offered at the St. Petersburg (now Petrograd) Institute for Railroad Engineers for several successive years to almost every student who took the entrance examinations in trigonometry, and not a single one of them was able to solve it. The question was raised by some whether the professors who offered this problem knew themselves how to solve it.

or $$\cos(3x+a-3x) = \frac{b}{4}[1+3\cos(x+3x)],$$

$$\cos a = \frac{b}{4}(1+3\cos 4x).$$

Hence, $$\cos 4x = \frac{4\cos a - b}{3b}$$

Substituting this value of $\cos 4x$ in (5), we find as the result of elimination of x,

$$b^2\left[10+\frac{8\cos a-2b}{b}\right] = 16, \text{ or after simplifying,}$$

$$b^2+b\cos a-2 = 0.$$

A NOTE ON THE LIMIT OF THE SUM OF AN INFINITE GEOMETRICAL SERIES.

By Albert Babbitt.

An infinite geometrical series may be represented either as

$$a_1,\ a_2,\ a_3,\ \ldots\ a_{n-1},\ a_n,\ \ldots,\ \text{or as}$$

$$a_1,\ a_1r,\ a_1r^2,\ \ldots\ a_1r^{n-2},\ a_1r^{n-1},\ \ldots$$

When r is less than 1, the limit of the sum is usually given by the formula

$$\operatorname{Lim}_{n=\infty} \Sigma = \frac{a_1}{1-r}.$$

Multiplying the numerator and the denominator by a_1, we get

$$\operatorname{Lim}_{n=\infty} \Sigma = \frac{a_1^2}{a_1-a_1r}$$

Since, however, $a_1r \equiv a_2$, we have therefore

$$\operatorname{Lim}_{n=\infty} \Sigma = \frac{a_1^2}{a_1-a_2}$$

In this form the formula is more convenient for computation when the infinite geometrical series is given by its first two terms.

The Indiana Association of Science and Mathematics holds its annual meeting in Indianapolis, March 5 and 6. An interesting and helpful program has been arranged. Every Science and Mathematics teacher in the state should be there and learn what the other fellow is doing.

DRAFTING IN DRESSMAKING CLASSES.[1]

By Agnes K. Hanna,
School of Education, University of Chicago.

The value of pattern drafting in school work depends largely on the interpretation of its function in the Household Arts course. If considered merely as a means of securing patterns by which garments are to be cut, its value is questionable, whereas when used properly as one step in training for a knowledge of good lines in dress and ability to fit, it has a most definite value and place.

The chief difficulty of much of the criticism that we hear, both adverse and in its favor, is that drafting is considered as an isolated subject having no distinct position in the general problem of garment designing and construction. Under these circumstances its use or disuse is largely a matter of personal inclination or interest in a rather mechanical process. Those who believe in it feel that girls should be taught to make their own patterns that they may be independent of commercial patterns. On the other side, we are assured that the cost of shop patterns is such a small factor that there is an actual loss in making patterns if one considers time as having monetary value and that the vital thing is not to teach girls how to get along without ready-made patterns, but to teach them to use them properly.

In regard to teaching pattern making by drafting as an end in itself, there should be little doubt as to the real value if the facts of the case are carefully considered. The average drafting course, even of high school, offers such limited practice that it is only the exceptional student who is able to successfully make even a plain pattern for different types of figures without supervision. This, of course, does not hold true when extended practice is offered. Also the constant changes in shapes and lines of gowns due to changes in fashions necessitate a closer study of the general outlines, position of seams, arrangement of fullness, etc. than the average girl cares to give for an occasional gown when she can get a ready-made pattern with the desired effect.

For the girl of unusual type of figure for whom the standardized pattern is impossible, pattern drafting would seem to be of great value, but unfortunately many of the drafting systems that are taught use average measurements for many of the lines, which it is easily seen would eliminate much of the value of a special pat-

[1]Read before the Home Economics Section C. A. S. & M. T., November 22, Hyde Park High School, Chicago.

tern. Ability to correct ready-made patterns is often of more value than the power to draft an original pattern under these circumstances.

It is almost invariably true that the systems of drafting that give the most facility and ease in pattern making are those that offer more mechanical devices for securing a result and require a minimum of attention to be given to the principles involved. If, therefore, pattern making is the end sought it would be of advantage to adopt one of these systems, whereas, if the study of lines and shapes is the object desired the system that requires attention and discrimination for every step in the construction of the draft is the most desirable one in spite of its complications. These two aims, therefore, would seem to be distinct and not to be secured by the same methods.

After weighing all of these factors the final element of our discussion is not, could this girl make all of her own patterns if properly taught, but does she really make them and to what extent does the personal or family sewing of the average girl offer practice in using this rather highly specialized ability. We have at our command only vague estimates of the place of sewing in present home life, but that it is one of the industries that is steadily being absorbed by the shop or factory is almost unquestioned. The amount of ready-to-wear clothing for sale in the shops is not only increasing in a remarkable degree, but the variety both in quality and kind is steadily tending to meet the needs of all economic classes. Another factor which gives evidence of the decrease of sewing done in the home is the extent to which the daughters of the household are going into work outside in the industries. The demands of the business world for a well-dressed appearance and the lack of time, not only to make her own clothes, but to keep in touch with the technic of costume designing and construction are making the girl whose day is spent in the office, shop and classroom depend upon the skilled worker and not herself for her clothing.

Without going into the details of the types of homemade garments and the average number of patterns purchased annually, I believe that the experience of most of us will prove the general statement that the commercial patterns for simple sewing are quite satisfactory with minor alterations for the person of average figure and that the amount of drafting necessary to keep a girl supplied with patterns would be so small that it would not offer sufficient practice to retain any skill in pattern making. For the per-

son of unusual figure, it is always possible to secure from the regular pattern makers patterns made to special measurements.

The general conclusions that we have reached so far are that pattern drafting as an end in itself does not meet a definite need of the girl doing her own sewing and that any system of drafting, chief value of which is ease in pattern making, is not desirable in general school work.

The introduction of trade schools into the public school systems of several cities brings to our attention another type of sewing class, those for vocational training in the needle trades. There is a decided division of opinion as to the function of drafting in these schools. The training in the needle trade given in the existing trade schools for girls aims to fit them for some branch of the machine operating trades or for the hand sewing trades of which dressmaking is the most skilled branch. In the machine operating trades cutting and designing is an absolutely separate division and has no relation to the acquisition of skill in machine operating. In the hand sewing trades a knowledge of designing, cutting and fitting has a more definite place, though the increasing specialization in dressmaking is tending to reduce the number of workers who have the opportunity to acquire skill along these lines.

This specialization is found at its greatest extreme in the large cities and as a result the training offered in schools such as the Manhattan and Boston trade schools, aims to secure the greatest amount of efficiency in the types of work open to these girls. When a girl is trained as a specialized worker on skirts, sleeves or waists, ability in pattern making or cutting is not an essential as such work is done by the cutter or forewoman. In the smaller cities where dressmaking shops are smaller and offer a greater opportunity to the girl with more general training, pattern making and fitting are considered part of the regular course.

It is not within the scope of this paper to discuss the educational policy of these schools and I have merely suggested it that we might more intelligently consider the value of drafting in a school where training is vocational rather than for home use.

At a recent convention of dressmakers where we were discussing the relation of the school and the needle trades, I was asked "Why do you teachers waste time on teaching drafting when we never use drafted patterns in dressmaking?" This might seem to be a most conclusive argument as to the futility of teaching draft-

ing in dressmaking classes for if patterns are never used, why teach the girls to make them.

Patterns can be made in three ways: by drafting, which we have been discussing, by free-hand cutting and fitting, a less accurate method than drafting and dependent upon an accurate eye and a knowledge of lines, and by modelling and draping on the figure. It is this last method that is used by dressmakers. Drafted patterns are only valuable for the materials that retain their firmness and shape when put on a curved surface. Any materials that mould to the form or lose the rectangular relation of warp and woof threads should be draped on the figure, not cut by a flat pattern. The same pattern used to cut out a firm light weight wool blouse and one of chiffon cloth will produce an entirely different effect. The chiffon cloth will sag and cling to the figure and the desired lines can only be produced by either draping and cutting the material directly without using a pattern, or by draping and cutting a pattern of some other fabric with identical qualities.

It can be easily seen from this why the tailor using firm silks, worsted and woolen suitings and linens and making garments where the slightest inaccuracy is noticeable uses drafted patterns, whereas the dressmaker with all grades of pliancy and sag to her fabrics models her linings and drapes her outside materials.

There is also another reason why modelling is a much more effective method of pattern making than drafting, for the dressmaker. The tailor made suit follows more or less conventional lines, but the product of the dressmaking shop shows an infinite variety of gowns, wraps and fancy suits demanding originality in design from the most simple effects to the most bizarre. It would require an absolute mastery of the geometrical relation of lines to secure these results by drafting, while the same effect could be far more easily and expediently secured by modelling the pattern on a form. One requires a highly specialized knowledge difficult to secure, which would be only effective on a few fabrics while the other can be used on all materials and needs merely the knowledge of lines and skill of hand that is constantly in demand in fitting.

There is one element that the dressmaker almost invariably neglects when she decries the value of drafting; that is, the accuracy of the resulting pattern. If the shoulder seam of an evening gown is ¼ inch farther forward on one side than it is on the other, it makes very little difference since it is covered by lace.

If the armhole is too large a small seam, again covered, rectifies this defect, which in a tailored coat of mohair might necessitate the recutting of an entire section.

While visiting one of our large technical schools a short time ago, I was shown eight or ten waist linings that had been modelled on the girls and padded out to use for forms on which to drape and fit their dresses. They were a most striking illustration of this very point. In all probability they fitted the girls extremely well, but there was not a single one of the group that had all of the lines true. It was an attempt to do a piece of work which required a knowledge of lines without having that knowledge.

This then would seem to be one of the objects of drafting—a study of line. By lines in dress we mean the general outline, the "hang" of a garment, the position of fullness, darts, etc., and the position of seams that define the shape of each section or part of the garment. A well-placed or a well-shaped seam can accentuate the beauty of a line of the figure, or if carefully considered, detract attention from a defect. A knowledge of lines is the end to be desired, it is the basis of style in a garment whether your skill is only equal to a shirt-waist or your creation is a ball gown.

I am not suggesting that a real knowledge of lines can be acquired by any short cut or formal method; I am merely advocating the use of drafting as one element in the study of the lines of gowns, its chief function being the consideration of the position of seams and effects produced by direction of the lines outlining the pattern. A secondary value resulting from drafting is the accuracy necessary in taking and using measurements. These same results can be secured by other methods. Intelligent use of ready-made patterns in the beginning with constant experimentation in changing the shape to produce different effects, as one's skill develops, will build up a body of information similar to that acquired by drafting but with a far greater expenditure of time. This seems to me to be the crux of the matter. Drafting as an end in itself we have proved to be of value only to the highly specialized pattern maker. Its value lies in its ability to offer a comprehensive and effective study of certain principles of line which are fundamental in garment construction; its essential value being the economy of effort which this study should secure in comparison with the more empirical method of experimentation.

With this interpretation of drafting the selection of the drafting system to be used in class work becomes a very vital matter.

The only systems that should be used are those that bring out clearly the fundamental principles which regulate the place and direction of each line drawn. There are about six different systems of drafting used in the high schools of various states. They vary from the purely mechanical type to the ones which have a definite explainable reason for the placing of every point and drawing of every line. The following points are the criteria of a good system:

1. The reason for every line should be definite and clear.

2. It should not require mechanical devices to draw curves as this takes away from eye training.

3. It should readily respond to variations in figures and should make as satisfactory a pattern for a 44″ as for a 36″ bust and for a 2 yard as for a 4 yard skirt.

4. It should use actual measurements for all lines drawn, not "averages" or proportions of other measurements.

Another factor which is of great importance in the drafting problem is the method of presentation. One of the greatest hindrances to effective work in drafting has been the current practice of dictating drafts. A class is given drawing materials and step by step they reproduce the directions dictated by the teacher; for example, draw line I two inches from the top of your paper and line II three inches from the left edge, place point A three inches from the corner on line I and point B two and one half inches from the corner on line II, connect with a curved line. This is continued throughout the entire pattern with the result that the attention of the class is concentrated not on why they are drawing a certain line in a certain way, but upon placing points A and B a certain number of inches from a given point. The only way to make pattern drafting effective, is to eliminate entirely this mechanical method and to make the drawing directly related to the figure for which the pattern is being drawn.

The problems of drafting in dressmaking classes would seem, therefore, to be the need first, for a broader interpretation of its function; second, a more thorough study of drafting systems and their values; and third, a more skillful presentation than is used in many of our schools.

BREAD FROM STONES.

By A. W. Nolan,
University of Illinois.

A circular entitled "Bread From Stones," written by Doctor C. G. Hopkins of the Illinois Experiment Station, has become an agricultural classic. It is now in its third edition and nearly 100,000 copies have been distributed into all parts of the United States. The circular tells the story of Doctor Hopkins' success in bringing back economically a wornout farm in Southern Illinois to profitable production.

The farm under consideration consisted of about 300 acres of poor gray prairie land and was purchased in November, 1903, for less than $20.00 an acre. It was known in the community as the "Poorland Farm," and Doctor Hopkins adopted that name for his farm. The work of restoration was begun at first on only 40 acres of the farm. This particular 40 was bought at $15.00 an acre. It had been agriculturally abandoned for five years prior to this purchase. It was covered with a growth of red sorrel, poverty grass and weeds. The land was sour, dead, and depleted of plant food. During the ten years following the purchase of the farm, the 40 acres received the following treatment:

1903—Fall—Purchased, $15.00 per acre.
1903—Fall—Applied one ton per acre fine ground rock phosphate.
1903—Fall—Plowed all above under for corn for next year.
1904—Spring and Summer—Corn crop.
1904—Fall—Applied limestone, two tons per acre.
1905—Spring—Soy beans.
1905—Fall—Wheat.
1906—Spring—Clover sowed in wheat
1907—Spring—Timothy and more clover.
1908 and 1909—Meadow and pasture.
1909—Fall—Applied rock phosphate.
1909—Fall—Plowed down for corn.
1910—Spring and Summer—Corn crop.
1911—Spring—Oats; volunteer clover appeared.
1912—Spring and Summer—Clover harvested.
1912—Fall—Plowed for wheat.
1912—Fall—Applied limestone, two tons per acre.
1913—Summer—Wheat harvested.

Note—Applied six loads per acre of barnyard manure once during the ten years.

Only 39 acres were in wheat, a lane having been fenced off on one side of the field. The yields were as follows:

One and one-half acres with farm manure only—11½ bushels per acre.

One and one-half acres with farm manure and one application of ground limestone—15 bushels per acre.

Thirty-six acres, with farm manure, two applications of ground limestone, and two of fine ground phosphate in the rotation as described above—35½ bushels per acre.

Here we have a yield of wheat about double the average land of the state. The practical farmer will naturally ask, "What did all this cost?" The average annual cost for the purchase, delivery, and application of the limestone and phosphate was $1.75 per acre. In the ten years then, the total cost was $17.50 per acre. Add to this the original cost, $15.00 per acre, making $32.50 and still you have pretty cheap land to produce double the average of the state. Doctor Hopkins puts it this way. "The average annual investment of $1.75 resulted in the increase of 24 bushels of wheat (35½-11½) per acre in 1913. Thus we may say that the previous application of these two natural rocks, or stones, brought about the production in 1913 of 864 bushels of wheat, an amount sufficient to furnish a year's supply of bread for more than a hundred people."

This story of the "Poorland Farm" is a remarkable instance of the conservation of one of our greatest resources, the soil. Conservation means a saving of the resource by a wise use of it. At the end of ten years of use the soil on the "Poorland Farm" is producing more wheat than the average production of the state, and at the same time its fertility is increasing year by year.

NEW PETROLEUM MAP OF THE UNITED STATES.

The United States Geological Survey has just printed a large, colored wall map showing the petroleum resources and the natural gas deposits of the United States, and also the thousands of miles of trunk oil pipe lines. The map shows the areas underlain by known oil pools and known gas pools, as well as general localities which are productive in either oil or gas, and also areas where there are noteworthy occurrences of either oil or gas but where there is no present production. The map is 49 by 76 inches, printed on the scale of 40 miles to 1 inch, in five colors. It is printed in two sheets and is sold, unmounted, by the Geological Survey, Washington, D. C., at $1 a copy. This map not only shows graphically the oil fields and pipe lines, but is an excellent general map of the United States.

PROBLEM DEPARTMENT.

BY I. L. WINCKLER,

Central High School, Cleveland, Ohio.

Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and solutions will be credited to their authors. Address all communications to I. L. Winckler, 32 Wymore Ave., E. Cleveland, Ohio.

Algebra.

411. *Proposed by A. Babbitt, Urbana, Illinois.*

Solve: $2^x = 4x$.

I. *Solution by Norman Anning, Clayburn, B. C., and Roy Berg, Chicago, Illinois.*

From the graph, the line, $y = 4x$, intersects the curve, $y = 2^x$, in two points, one having abscissa 4, and the other having an abscissa between 0 and 1. Hence $x = 4$ is one solution.

To find the other solution by trial;

x	2^x	$2^x - 4x$
1	2	−2
0	1	1
$\frac{1}{3}$	1.26	−.07
.3	1.231	.031
.31	1.2397	−.0003
.3099	1.23962	.00002
.309907	1.239629	.000001

These figures were obtained by using seven-p'ace logarithms of 2, 1.23 and 1.24 and are probably untrustworthy beyond the value.

$$x = .3099.$$

II. *Solution by T. M. Blakslee, Ames, Iowa.*

It is easily seen that $x = 4$ is a solution.

Also that there is another value of x between 0 and 1.

For an approximation to this value use the familiar formula,

$$a^x = \sum_0^\infty \frac{(\log_e a)^n x^n}{\lfloor n},$$

omitting terms containing higher powers of n than the first.

Then $2^x = 1 + .693x = 4x$. $\therefore x_1 = .3$.

By trial and error method, $x_2 = .31$, and in the same manner more decimals if desired.

III. *Solution by Walter C. Eells, Annapolis, Maryland.*

By plotting the exponential function 2^x and the straight line $4x$, 4 is suggested as a point of intersection of the two curves. Actual test shows this is the desired solution.

The method will suffice for the solution of the more general equation $2^x = ax$ to any desired degree of accuracy.

It is interesting to notice that the more general equation $2^x = ax$ (a an integer) has integral solutions if and only if a is of the form $2^{2^n - n}$ ($n = 0, 1, 2, 3, \ldots$), and that this integral solution is $x = 2^n$.

The given equation results from the more general form when $n = 2$.

For $n = 1$, the equation is $2^x = 2x$ and there are *two* solutions, $x = 1$, $x = 2$. Otherwise there is only one integral solution.

For $n = 3$, $x = 8$, and for $n = 4$, $x = 16$.

IV. *Solution by James H. Weaver, West Chester, Pa.*

From the given equation $2^{x-2} = x$. (1)

$\therefore$ x is some power of 2. Let $x = 2^p$. (2)

Substituting in (1), $2^{2^p-2} = 2^p$. $\therefore 2^{2^p-2}-p = 1$

$\therefore$ $2^{2^p-2}-p = 0$, and $2^p-2 = p$, or $2^{p-1}-1 = \frac{p}{2}$ (3)

By Fermat's Theorem, $2^{\frac{p}{2}-1} \equiv 0 \pmod{\frac{p}{2}}$ (4)

And since in (3) $2^{p-1}-1 = \frac{p}{2}$, $\therefore 2^{\frac{p}{2}-1} = 0$.

This follows because $2^{\frac{p}{2}-1}$ is less than $2^{p-1}-1$.

$\therefore 2^{\frac{p}{2}-1} = 1$. $\therefore \frac{p}{2} - 1 = 0$, and $p = 2$.

$\therefore$ from (2), $x = 4$.

412. *Proposed by F. X. Karrer, Nome, Alaska.*

A jeweler repairing a watch, placed the hour-hand upon the minute-hand pinion, and the minute-hand upon the hour-hand pinion and then set the watch at six o'clock, which was the correct time. He then gave the watch to the owner. The latter sometime later wishing to know the time of day, and, not knowing that the hands had been changed, looked at his watch and found that it registered the correct time. What was the time of day?

I. *Solution by Stanley F. Atwood, Dayton, Washington.*

Let us compare the watch which has its hands exchanged, with a correct watch. The former will indicate exact time when its hands are coincident with those of the latter. The minute hand of the incorrect watch is at 12 and the hour hand of the correct watch is at 6 when the watch is set. Since these two hands move at the same rate they will always be 30 minute-spaces apart. The same is true of the hour hand of the incorrect watch and the minute hand of the correct one. When the two minute hands are together the two hour hands are 30-minutes-spaces behind, and coincident also. We have then only to find the time after 6 o'clock when the hands of a true watch are opposite. Obviously, this is not between 6 and 7, so we find the time between 7 and 8. (It occurs once every hour so we find for only one, the first.)

Let $x =$ the number of minute spaces the hour hand goes through.

Then $12x =$ the number of minute spaces the minute hand goes through.

$35+x =$ the position of the hour hand.

$12x =$ the position of the minute hand.

$12x+30 = 35+x$.

$x = 5\frac{5}{11}$.

$12x = 5\frac{5}{11}$ minutes after 7, when the hands are opposite and also when the incorrect watch registers correct time.

II. *Solution by M. G. Schucker, Pittsburgh, Pa., and Daniel Kreth, Wellman, Iowa.*

One hour afterward the hour-hand is at 6, the minute-hand at one. The correct time is seven o'clock. The hour-hand is 5 minute spaces in arrears of correct time, the minute-hand is 5 minute spaces ahead of correct time. As the hour-hand gains $\frac{11}{12}$ of a minute space on correct time in going one minute space and as the minute-hand loses $\frac{11}{12}$ of a space on correct time every minute it will appear that both hands register correct

time in $5 \div 11/12$ or $5\frac{5}{11}$ minutes after 7 o'clock; or, whenever the hands are in opposition, i. e., at $8:10\frac{10}{11}$, $9:16\frac{4}{11}$, . . .

Geometry.

413. *Proposed by Nelson L. Roray, Metuchen, N. J.*

ABCD is a parallelogram, E any point on AB, G any point on CD, AG and GB intersect DE and EC at H and F, respectively. Prove the line HF divides the parallelogram into two congruent trapezoids.

I. *Solution by Herbert Wharton, West Chester, Pa.*

Let HF meet AD at X and BC at Y.

Draw the diagonal DB, meeting XY at O. Also draw DY and XB.

The triangles BOY and XDO are similar. (Having equal angles.)

$\therefore$ DO : OB = XO : OY.

In the triangles DOY and XOB; the vertical angles are equal and the two adjacent sides are proportional.

$\therefore$ DOY and XOB are similar. And angle XYD = angle BXY.

$\therefore$ These angles being alternate interior angles of two lines the lines DY and XB are parallel. $\therefore$ XD = BY. And XA = CY.

Then the two trapezoids, ABFH and HDCF are equivalent, having equal bases and equal altitudes.

$\therefore$ HF divides the parallelogram into two equivalent trapezoids.

II. *Solution by Norman Anning, Clayburn, B. C.*

Choose axes through the center parallel to the sides.

Suppose A, E, B, C, G, D have the co-ordinates $(-p, -q)$, $(r, -q)$, $(p, -q)$, (p, q), (s, q), $(-p, q)$.

Then the following lines have the following equations:

$$\text{DE}, \quad 2qx+(p+r)y = q(r-p);$$
$$\text{AG}, \quad -2qx+(p+s)y = q(p-s);$$
$$\text{BG}, \quad 2qx+(p-s)y = q(p+s);$$
$$\text{CE}, \quad -2qx+(p-r)y = -q(p+r).$$

The co-ordinates of H are found from the first pair,

$$\left(\frac{rs-p^2}{2p+r+s}, \frac{(r-s)q}{2p+r+s}\right).$$

Similarly, F, from the second pair,

$$\left(\frac{p^2-rs}{2p-r-s}, \frac{(s-r)q}{2p-r-s}\right).$$

The equation of the line HF,

$$q(s-r)x-(p^2-rs)y = 0,$$

has no constant term.

Therefore HF passes through the center and, consequently, divides the parallelogram into two congruent figures.

414. *Proposed by H. C. McMillin, Washington, Kansas.*

Construct a triangle given the circumcenter, orthocenter, and one vertex.

I. *Solution by James H. Weaver, West Chester, Pa.*

Given: O the circumcenter of triangle ABC, O′ the orthocenter, and vertex A.

Through A, B and C draw A′B′, A′C′ and B′C′, parallel, respectively, to AB, AC and BC. Then A′B′, A′C′ and B′C′ are twice AB, AC and BC, respectively.

Triangle ABC is similar to A′B′C′ and O′ is the circum-center of A′B′C′. Draw O′A, O′C′, OC, and also OE perpendicular to BC.

Triangles OEC and O'C'A are similar.

Also since $B'C' = 2BC$, $C'A = 2CE$.

$\therefore$ $OE = \frac{1}{2}O'A$.

The construction then is as follows:

Draw O'A and bisect it in the point X. Draw OE parallel to O'A and equal to AX. Draw BC through E, perpendicular to OE. The points where this intersects the circle with O as center and OA as radius will be the other two vertices of the triangle ABC.

II. *Solution by Norman Anning, Clayburn, B. C.*

Let S be the circumcenter and O, the orthocenter of the required triangle ABC. Suppose points A, O, S given.

Lemma: Triangles, BOC, COA, AOB have the same circumradius as triangle ABC.

For, circumradius of triangle BOC

$$= \frac{BC}{2 \sin BOC} = \frac{BC}{2 \sin (180° - A)} = \frac{BC}{2 \sin A}$$

Hence the construction,

With center S, describe the circumcircle through A. Describe the two circles through A and O which have the radius SA. These two circles will cut the first in the remaining vertices, B and C.

III. *Solution by William Feuerwerger, New York, N. Y.*

Let S, O and A be the circumcenter, orthocenter, and vertex, respectively. With S as a center and SA as a radius construct a circle.

Join AO and prolong it to cut this circle at Q. Bisect OQ at P and draw chord BC perpendicular to AQ at P. Join AB, AC.

Triangle ABC is the required one.

415. *Selected.*

Prove by elementary geometry that $d^2 = R^2 - 2Rr$, where R is the radius of the circum-circle, r the radius of the in-circle of a triangle and d is the distance between these centres.

Solution by T. M. Blakslee, Ames, Iowa, and William Feuerwerger, New York, N. Y.

Let O and P be the circum-center and in-center of triangle ABC, respectively. Prolong CP to meet circum-circle in D. Draw DO, prolonging it to meet circum-circle at E. Join EB, OP, and BD. Draw OP and let it meet circum-circle at K and L. Draw OF perpendicular to AC.

CP bisects $\angle ACB$. $\therefore$ arc DA = arc DB.

$\therefore$ $\angle ABD = \angle DCB$. Because BP bisects $\angle ABC$, $\angle PBA = \angle PBC$. $\therefore$ $\angle PBD = \angle PCB + \angle PBC = \angle DPB$.

$\therefore$ DP = DB. The right triangles EBD and CFP have the acute angles E and C equal. $\therefore$ They are similar and $PC \cdot BD = DE \cdot PF$, or

$PC \cdot PD = DE \cdot PF$. But $PC \cdot PD = OK \cdot OL$.

$\therefore$ $DE \cdot PF = OK \cdot OL$, or $2Rr = (R+d)(R-d)$.

$\therefore$ $d^2 = R^2 - 2Rr$.

CREDIT FOR SOLUTIONS.

401. M. G. Schucker. (1)

404. M. G. Schucker. (1)

407. M. G. Schucker. (1)

411. Norman Anning, Roy Berg, T. M. Blakslee, Albert Early, Walter C. Eells, Daniel Kreth, James H. Weaver, one incorrect solution. (8)

412. Norman Anning, Stanley F. Atwood, J. A. Bell, Daniel Kreth, M. G. Schucker. (5)

413. Norman Anning, T. M. Blakslee (3), William Feuerwerger, 2 incorrect solutions. (7)

414. Norman Anning, William Feuerwerger, James H. Weaver. (3)

415. Norman Anning, T. M. Blakslee, William Feuerwerger. (3)

Total number of solutions, 29.

PROBLEMS FOR SOLUTION.

Algebra.

426. *Proposed by the Editor.*

Solve:

$$x(y+z-x) = a. \quad (1)$$

$$y(z+x-y) = b. \quad (2)$$

$$z(x+y-z) = c. \quad (3)$$

Geometry.

427. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Given a rectangle whose base is to its altitude as 5 : 1. Cut it into four parts so that they may be joined together to form a perfect square.

428. *Proposed by Henry B. Sanders, New York, N. Y.*

ABCD is a quadrilateral having AB = AD, and $\angle C = \angle B + \angle D$; prove AC = AB.

429. *Proposed by N. P. Pandya, Sojitra, Dt. Petlad, India.*

Construct a triangle ABC, A being the point of contact of two given circles having an internal contact, BC a chord of the larger circle tangent to the smaller, and having given AB : AC = m : n.

Trigonometry.

430. *Proposed by Daniel Kreth, Wellman, Iowa.*

The perimeter of a triangle is 120, the radius of the inscribed circle 10, and the vertical angle 70°. Construct the triangle and determine its sides.

[The Editor would like a new supply of interesting problems for this department.]

LIVE CHEMISTRY.

By H. R. Smith,

Lake View High School, Chicago.

Again, we urge all chemistry teachers to send us material to print telling how you teach this subject in a live way. We are depending much on the help of those who were at the November meeting of the Central Association. We are told that the number of students studying chemistry has decreased during the last ten years. Whatever may be the cause of such a decrease we are sure that every chemistry teacher should be more alert to answer the question, "How can my teaching of chemistry better serve the needs of my community?"

Chemistry stands second to no subject in the curriculum for giving a student mental training or useful knowledge. But it is a peculiar study. The novice does not readily acquire an insight of the chemical world without aid and direction. It is common experience to find that few, if any high school students, not having studied the subject, really know what chemistry is. Teachers should make more of an effort to open up the

subject to the whole school. All three of R. K. Duncan's books, "New Knowledge," "Chemistry of Commerce," and "Some Chemical Problems of Today," should be in every school library where chemistry is taught. Read a few pages from them to your classes and then give them access to the books. One student who started "The Chemistry of Commerce" used every spare minute until he had finished it, and then decided to be a chemist. Other books of similar nature are "Triumphs and Wonders of Modern Chemistry" by Geoffrey Martin, "Modern Science Reader" by R. M. Bird. Good Housekeeping Magazine has a valuable department conducted by Dr. Harvey Wiley, and the Ladies' World by L. B. Allyn. Food Commissions of different states publish valuable reports of their work on foods. Illinois families may each have one for the asking. Address, Food Commissioner, Manhattan Bldg., Chicago, "Report of 1912-13."

The Indiana Commissioner of Indianapolis has published an interesting bulletin on "Medical Frauds." Write for one and show your students the practical value of a knowledge of chemistry. Have some of your best students make charts of chemical subjects and value of the same to display where all students may see them. A chemistry teacher of Pittsburg, Pa., J. Gordon Ogden, has this plan:

"Once a week I devote one-half hour to a meeting of a 'Chemical Research Society' formed of the students of the class. I take a seat with the pupils, and a leader, who has previously read up on a subject, *and has done some work that the other students have not* along that special line, talks about some phase of practical work, and exhibits a few diagrams which he has placed upon the blackboard early that morning, before school convened. Generally the student, under my direction, has gone out to some mill, factory, or store, where special information may be readily obtained. For example, last week we had a very interesting 'paper' from a Jewish boy whose father manufactures incandescent mantles. The boy brought samples of all material, and the whole process was intensely interesting to teacher and pupil alike. I find that this 'Research' society is my best 'bower,' as the students appreciate that it is an effort to give them a chance for individuality and they appreciate it."

We wish to repeat that the chief value of this work is going to come to those schools, as a reaction from the efforts of the chemistry teacher to treat his subject in a live way. We want *every* chemistry teacher *to join with us in trying to raise the efficiency of the teaching of Chemistry.*

Coal Gas Experiment.

I. Test of Reducing power of the Gas. Place some Cu O in a short piece of ¼ inch glass tubing. Connect by means of rubber hose with gas connection. Support with a burette clamp. Turn on a gentle flow of gas. Ignite at the end of the glass tubing. Heat the oxide in the tube with a bunsen flame. What change occurs? What is formed? Repeat using lead oxide. What results are obtained with the lead oxide? What constituents of the gas causes the reducing action? Write the probable reactions.

II. Test the Gas for Carbon dioxide by bubbling it through limewater. Arrange apparatus according to oral instructions. Ignite the escaping gas. Results? Reaction? Should gas contain much carbon dioxide?

III. Test the Gas for Hydrosulphuric acid. Using the same apparatus as in II above, replace the limewater with a piece of filter paper moistened in lead acetate solution. Allow the gas to pass through the tube for three minutes, burning the gas which escapes. If the paper is darkened, hydrosulphuric acid is present. What results were obtained? What is the black

compound formed on the filter paper? (If any formed). Should illuminating gas contain hydrosulphuric acid? Why?

IV. Test the Gas Pressure. Use same apparatus as in II above. Make the gas connection at the exit tube. Place about an inch of water in the test tube. Insert stopper firmly. Note how high the water exends up the tube. Turn on the gas. Note how high the column of water is raised? A pressure of 1½ inches burns well. The pressure should be between 1 and 5 inches.

C. W. BOTKIN,
Ottumwa, Iowa.

The season for honey brings with it each year an increased demand. As good honey sells for prices ranging from 15 to 30 cents per pound, the temptations to use glucose in strained honey is very great indeed. Here are two tests for glucose:

1. Dextrine is found in all commercial glucose. Dextrine is insoluble in 95 per cent alcohol. Put about five c. c. of strained honey in a test tube and add twenty c. c. of 95 percent alcohol. Shake vigorously. If only a slight cloudiness appears, no glucose is present. If the solution is cloudy, too thick, it is a very good indication that glucose has been added as an adulterant.

2. All commercial glucose has a trace of calcium sulphate. To the honey diluted four times with distilled water, add a few drops of ammonium hydroxide and then some ammonium oxalate solution. A white precipitate indicates the presence of commercial glucose.

It is well to test glucose first, or the class will expect too large a precipitate with the ammonium oxalate.

Can you give us some *new* experiments along these lines?

1. For girls who expect to take up a course in nursing in some good hospital.
2. For boys who expect to work in iron and steel, as mechanical or electrical engineers.
3. For boys who expect to become students of pharmacy and medicine.
4. Paper and parchment making.
5. Dyeing of cloth, leather, wood baskets, etc.
6. Tanning of leather and curing of meats.
7. Products of coal tar.
8. Testing of coal.
9. Laundry and cleaning experiments.
10. Agriculture experiments.
11. Paints, varnishes and other wall coverings.
12. Testing for poisons in the presence of food and other things likely to be in stomach contents.
13. Tests for oil adulterants, as olive oil, linseed oil.
14. Analysis of inks.
15. Experiments with clay, cement and glazes.
16. Making mirrors.
17. New "stunts" in photography.

A. C. NORRIS,
Rockford, Ill.

ARTICLES IN CURRENT PERIODICALS.

American Botanist for November; *Joliet, Ill., $1.00 per year:* "The Mistletoe," Willard N. Clute; "The Fringed Gentian," W. W. Barley; "A Common Wild Flower and its Legends," Maud Going; "Pitcher Plants," Mrs. G. T. Drennan; "An Abnormal Twayblade," Edwin D. Hull; "Sweet Flag and Calla," Adella Prescott.

American Mathematical Montly for December; *5548 Kenwood Ave., Chicago; $2.00 per year:* "The Theorem of Rotation in Elementary Mechanics," E. V. Huntington; "The Napier Tercentenary Celebration," Florian Cajori; "The Paris Report on Calculus in the Secondary Schools"; "Sur un Paradoxe Algébrique Apparent," G. Loria.

American Naturalist for January; *Garrison, N. Y.; $4.00 per year, 40 cents a copy:* "Some Fundamental Morphological Objections to the Mutation Theory of De Vries," Edward C. Jeffrey; "The English Rabbit and the Question of Mendelian Unit-character Constancy," W. E. Castle and Dr. Philip B. Hadley; "On the Number of Rays in Asterias tenuispina Lamk. at Bermuda," W. J. Crozier.

Journal of Botany, for December; *Brooklyn, Botanic Garden, Brooklyn, N. Y.; $4.00 per year, 50 cents a copy:* "The Expulsion of Ascospores from the Perithecia of the Chestnut Blight Fungus, Endothia Parasitica (urr.) And.," F. D. Heald and R. C. Walton; "Gliding Growth and the Bars of Sanio," J. G. Grossenbacher; "Notes on the Anatomy of the Punctatus Gall," Alban Stewart.

Journal of Geography for January; *Madison, Wis.; $.100 per year, 15 cents a copy:* "Essentials of Modern Geography and Criteria for Their Determination," G. J. Miller; "Current Geographical Notes—Industries of Nice and Riviera; The New York Barge Canal"; "Supplementary List of Material on Geography Which May Be Obtained Free or At Small Cost" (with nearly 500 titles), Mary J. Booth.

Guide to Nature for December; *Agassiz Association, Sound Beach, Conn.; $1.00 per year, 10 cents a copy:* "An Efficient Student and Protector of Birds," Neil M. Ladd; "A World of War," Edward E. Bigelow; "Children and the Study of Birds," "The Heavens in December," Eric Doolittle.

L'Enseignement Mathématique for November; *Stechert & Co., West 25th Street, New York; 15 francs per year, 2 francs a copy:* "Une Leçon d'algèbre élémentaire sur les polynômes biquadratiques et doublement quadratiques," C. Cailler; "Sur l'orthogonalisation de fonctions," U. Broggi; "Sur une application de la théorie des nombres à la méchanique statistique et à la théorie des perturbations," H. Weyl; "Le problème des trajectoires en coordonnées tangentielles," E. Turrière.

Mathematical Gazette for December; *G. Bell & Sons, Portugal Street, Kingsway, London; six nos. 9s. per year, 2s. 6d. a copy:* "Kinetic Energy, Divided into Molar Energy and Available, Internal, or Molecular Energy," Sir George Greenhill; "Singular Solutions of Differential Equations of the Second Order," Prof. H. Hilton; "Berkeley and Newton," W. D. Evans; "The Achievements of Great Britain in the Realm of Mathematics —Continued," Prof. Gino Loria.

Popular Astronomy for February; *Northfield, Minn.; $3.00 per year, 25 cents a copy:* "Reflections. Halley's Comet, Venus and the Crescent Moon, Plate VI, Frontispiece"; "Longitude of the Drake University Observatory by Wireless," D. W. Morehouse; "A Photograph of a Meteor Trail, with Plate VII," Joel H. Metcalf; "Claudius Ptolemaeus," Charles Nevers Holmes; "A Practical Explanation of the Gyroscope," C. F. Bugbee; "Sunspots Caused by Planets," J. S. Ricard; "The Prismatic Astrolabe, a New Instrument for Determining Latitude and Time by Equal Altitudes," David Rines; "Remarks on Meteor Observing and the Geminid Meteors of December, 1914," Nels Bruseth.

Popular Science Monthly for January; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "Geography in Russian History," William E. Lingelbach; "Geological Methods in Earlier Days," John J. Stevenson; "The Cinchona

Botanical Station," Duncan S. Johnson; "The Indian's Health Problem," Dr. Charles A. Eastman; "What Animal Experimentation has Done for Children," Dr. Henry Dwight Chapin; "Europe's Dynastic Slaughter House," William J. Roe; "Training for Action," H. W. Farwell; "Delusions," Dr. Shepherd Ivory Franz; "Ductless Glands, Internal Secretions and Hormonic Equilibrium," Dr. Fielding H. Garrison.

Psychological Clinic for January; *Woodland Ave. and 36th Street, Philadelphia; $1.50 per year, 20 cents a copy:* "Six Weeks with a Supposedly Hopeless Case," Alice C. Hinckley; "Improvement of Dental Hygiene in the High School, with Relation to Efficiency," Wilfred L. Foster; "Obstructed Breathing and Memory," Felix Arnold, Ph.D., Principal Public School No. 30, New York City.

School World for January; *Macmillan and Company, London, Eng.; 7s. 6d. per year, 6 pence a copy:* "The Place of the Text-Book in Mathematical Teaching," Edmund Lightley; "Manual Training as an Introduction to Experimental Work," T. S. Usherwood; "Some Experiments in Practical Geography," C. B. Thurston; "Pictures in the Class-Room," E. M. Carter; "Mathematics and Science as Part of a Liberal Education," W. D. Eggar.

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 8; *Otto Salle, Elssholzerstr. 15, Berlin W. 57, Germany; M. 4 per year, 60 Pf. a copy:* "Ernst Grimsehl," Prof. Kexferstein; "Photogrammetrie in der Schule," Dr. P. Riebesell; "Die Luftsäcke der Vögel und ihre Bedeutung für das Problem des Vogelfluges," Dr. O. Rabes; "Zur Lehre von den Harmonikalen," Prof. Jos. Moser; "Eine bequeme Berechnungsweise des Elferrestes," E. Hylla; "Ueber eine arithmische Reihe," Oberlehrer N. Agronomow.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht Aller Schulgattungen for November; *B. G. Teubner, Leipsic, Germany; 12 numbers, M. 12 per year:* "Ueber Magische Quadrate. Anzahlbestimmungen, Vorkommen auf Amuletten," Dr. W. Ahrens; "Ueber die Anwendung der Geometrie auf Elementare Aufgaben der Mathematischen Geobraphie," Dr. C. Schoy; "Eine Neue Methode zur Angenäherten Summation Unendlicher, Schwach Konvergenter Reihen," Prof. Dr. A. Flechsenhaar; "Die Behandlung der Radioaktivität im Unterricht," Dr. P. Bräuer; "Eine Eigenschaft der Gemeinen Brüche"; "Einige Bemerkungen über die Teilbarkeit der Zahlen durch 7," R. Krahl; "Anschauliche Herleitung von Reihensätzen," Heinrich Simon; "Ein neuer Zerlegungsbeweis des Pythagoreischen Lehrsatzes," F. Gutheil; "Ableitung des Pythagoras aus Inhaltsgleichen Parallelogrammen," Gg. Heinrich. For December: "Der Mathematisch-naturwissenschaftliche Unterricht im Dienste der militärischen Vorbereitung der Jugend," Direktor W. Lietzmann; "Pol und Polare im Unterricht der Analytischen Geometrie," Prof. Dr. J. Dronke; "Das Verbesserte Dritte Kepplersche Gesetz," Karl Boecklen in Chicago; "Ueber das Verhältnis der Physikalischen Schülerübungen zum Fortlaufenden Klassenunterricht auf der Unterstufe der Mittelschulen," Max Prodinger.

Photo Era for January: "Photography Without a Microscope," E. J. Wall, F. R. P. S.; "A Practical Flashlight-Apparatus," Walter S. Meyers; "The Bromoil-Process in Portraiture," Dr. Emil Mayer; "Is There a Place Left for Straight Photography?" Sigismund Blumann; "Foregrounds," William S. Davis; "The Metronome as a Darkroom-Clock," Charles Travis; "Pictorial Landscape-Photography—Part III," Paul Lewis Anderson.

BOOKS RECEIVED.

Stories From Northern Myths, by Emilie Kip Baker. Pages ix+276. 13.5x19.5 cm. Cloth. 1914. The Macmillan Co., New York.

A Textbook on General Physics for Colleges, by J. A. Culler, Miami University. Pages x+321. 15x22.5 cm. Cloth. 1914. $1.80 net. J. B. Lippincott Co., Philadelphia.

Chemistry of Common Things, by Raymond V. Brownlee and Robt. W. Fuller, Stuyvesant High School, and Wm. J. Hancock, Erasmus Hall High School, and Jesse E. Whitsit, DeWitt Clinton High School, all of New York City. Pages viii+616. 14x19.5 cm. Cloth. 1914. Allyn & Bacon, New York.

Spring Flora, for Beginners and Amateurs, by W. A. Kellerman, H. A. Gleason and John H. Schaffner, Ohio State University. Pages xiii+205. 14x19 cm. Cloth. 1914. Geo. W. Tooill, Columbus, Ohio.

Chemistry in the High School, Parts 2 and 3, by E. P. Schoch, University of Texas. 210 pages. 15x22 5 cm. Paper. 1914. University of Texas, Austin, Tex.

Introduction to Laboratory Physics, by Lucius Tuttle, Jefferson College, Philadelphia. Pages ix+137. 13x18.5 cm. Cloth. 1915. Published by Jefferson Laboratory of Physics.

Aus Natur und Geisteswelt. Der Untergang der Welt und der Erde in Sage und Wissenschaft, by Prof. D. M. B. Weinstein. 107 pages. 12.5x18.5 cm. Cloth. 1914. B. G. Teubner, Leipzig.

Laboratory Furniture for Educational Institutions, from the Kewaunee Mfg. Co., Kewaunee, Wis. 262 pages. 15x22 cm. Cloth. 1914.

Journal of the Proceedings and Addresses of the 52nd Annual Meeting of the National Education Association . Pages xii+928. 15x23 cm. Cloth. 1914. Secretary's Office, Ann Arbor, Michigan.

BOOK REVIEWS.

College Physiography, by the Late Ralph S. Tarr of Cornell University, and Lawrence Martin, University of Wisconsin. Pages xxii+837. 16x22.5 cm. Cloth. 1914. $3.50. The Macmillan Co., New York.

This work by the late Prof. Tarr, is surely a monument to his memory, and represents only a part of the great work of this nature that he had in contemplation before he died. He left it in an unfinished state, but under the able editorial direction of Prof. Martin, it has been put in splendid condition. The book throughout discloses the genius possessed by its author. In it is embodied the life work of the man, and we find that its statements and authorities are beyond question. It is a book that all people in any way interested in the character and knowledge of the earth, should possess. It is not complete, of course, from all points of view, because the subject is too large to be covered in one text of this character. It is divided into three parts,—Part I, "The Planet and the Lands," consisting of 629 pages; Part II, "The Hydro-Sphere," of 45 pages; and Part III, "The Atmosphere," of 105 pages. There is a complete index appended of 23 pages. In the text are found 503 half-tones and figures, together with 10 colored maps. There are bibliographies and references to literature scattered throughout the book, especially at the end of many chapters. The major paragraphs all begin with the subject printed in boldfaced type. The text is written in an entertaining and fascinating style such that the amateur reader and student will be attracted to its pages. For the professional man there are hosts upon hosts of points which he will be glad to study and compare with his own point of view. It is one of the best texts of the kind yet published. Mechanically it represents a high class of book making. It doubtless will have an extensive sale. C. H. S.

The Naturalist's Directory, by S. E. Cassino, Salem, Mass. 199 pages. 13x19 cm. Cloth. 1914. Price $2.58 including carriage. Samuel E. Cassino, Salem, Mass.

This is a very helpful book to all people directly interested in those who come under the head of naturalists. It contains the title, position, address,

degrees, line of work, etc., of many hundred naturalists in all parts of the world. Of course there are many names that are not included, doubtless owing to the fact that these people did not communicate with the author of the book, in time. It is a valuable text which will take its place on the shelf alongside of "Who is Who." C. H. S.

School Discipline, by Wm. C. Bagley, University of Illinois. Pages xiv+259. 13x19.5 cm. Cloth. 1914. $1.25 net. The Macmillan Co., New York.

The times are just ripe for the reception of this remarkably interesting, progressive, and in every respect up-to-date book on School Discipline. Any word that the reviewer may have to say concerning it, is of a complimentary nature. It is written by one thoroughly competent to write on the subject, and he has produced a text which shou'd be in the hands of every progressive teacher in the land to be read and studied. Too many instructors carry the idea that they know all about how to govern their classes or manage their schools, and many are not willing to be taught in these phases of instruction. These people ought to get out of the system, because they have no business there. Only those teachers who are willing to be taught and who are anxious to learn, should have anything to do with the education of our youth. There are fourteen interesting chapters in this text, and a series of exercises is appended to each chapter. There are many references to other books and texts. The book is written in a most charming and interesting style, and printed on paper which is not highly calendared, thus removing the glare and direct reflection of light which is so trying to the eyes. There is appended a complete index of seven pages. The publishers should push strenuously the sale of this volume. C H. S.

A Handbook of Vocational Education, by Joseph S. Taylor, District Supt. of Schools, New York City. Pages xvi+225. 1914. Cloth. $1.00. The Macmillan Co., New York.

A book which is very timely in its discussion of this phase of educational work. It is written by one who has made an intimate study of educational work in many directions, especially as it is being carried out in this country. It is a book that all folk interested in vocational education should read and carefully study. There are in its contents twelve chapters. Chapter I is a general introduction to the subject. Chapter II is Industrial Education in Europe. Chapter III is Industrial versus Manual Training. Chapter IV, The Intermediate School. Chapter V, The Continuation School. Chapter VI, the Training of Vocational Teachers. Chapter VII, Vocational Guidance. Chapter VIII, Apprenticeship and Compulsory Education. Chapter IX, Conclusion. Chapter X, Topics for Discussion and Investigation. Chapter XI, Bibliography. Chapter XII, is an appendix containing subject matter on many phases of this work. There are in the text a number of full page half-tones taken from schools where vocational work is actually being done. The manner of treatment is interesting and to the point. It is printed on uncalendared paper, in large type, and double leaded. It will doubtless have a wide circulation. C. H. S.

"Principles of Cooking," by Emma Conley, Inspector of Domestic Science for Wisconsin. 206 pages. 12.5x19 cm. Cloth. 1914. 52 cents.

"Nutrition and Diet," by same author. 208 pages. 13x19 cm. Cloth. 1914. 60 cents. American Book Co.

These two splendid books have been written by a past master in the art of domestic science. They are written in a pleasing and interesting style, and it is possible for a teacher to use them in her classes with the least expenditure of time and energy. The pupils, too, will be interested in

what the books have for them. The texts are not merly cook books, but are filled with suggestions and hints on how to do things in applied household science. They will materially assist the young and inexperienced teacher in getting started with her classes in the right direction, and will keep the experienced teacher from too narrow a project in her instruction. The books should have, and doubtless will have, a wide circulation. Mechanically, they are representative of the highest type of book making.

C. H. S.

Vocational and Moral Guidance, by Jesse B. Davis, Central High School, Grand Rapids, Mich. Pages viii+303. 13.5x19.5 cm. Cloth. 1914. $1.25. Ginn & Co., Boston.

This is a splendidly written work, and appears to meet a demand for something of this nature which has been in teachers' minds for a long time. There are many schools which are now introducing vocational work, that have very little knowledge of the ethics of it, and which simply open the course because there is a popular demand for it. Just how to make the work of the highest efficiency, the directors of the school may think they know; but if they will read and study this particular text, they will find that they will gain a fund of information and knowledge which will help them to make their vocational course or courses, much more efficient. The book is divided into two parts,—Part One being Vocational and Moral Guidance Through Education. Part Two is How Some Practical Workers Have Obtained Results. Scattered through the text, especially at the end of most of the chapters, there are splendid bibliographies. There is a very complete index of five pages, also. The text apparently recognizes both the practical and the theoretical sides of the subject. It should have a wide circulation.

C. H. S.

Engineering Workshop Drawing, by Henry J. Spooner, Polytechnic School of Engineering, London, Eng. Pages viii+128. 23.5x17 cm. Paper. 1914. 50 cents net. Longman, Green & Co., New York.

This certainly is one of the best books of the kind that have recently been put on the market. It is written by a past master of the subject. The most recent inventions and ideas used in drawing are illustrated and discussed here. At the very outset the author gives some splendid instructions and illustrations as to how the various drawing instruments should be used and handled. The nature of the drawings is progressive, from the more simple ones to those of a complicated nature, and on to those of practical every-day machine shop work. There are 618 different drawings in the book, and from this one may judge of the universal character of the work treated. The volume demands a large circulation, and doubtless will have it.

C. H. S.

Plane Geometry, by M. J. Newell, Instructor in Mathematics, High School, Evanston, Ill., and G. A. Harper, Instructor in Mathematics, High School, Kenilworth, Ill. Pages xii+243. 14x19 cm. 1914. Row, Peterson & Co., Chicago.

Though the authors have not attempted to present a new and original treatment of the subject, there are a number of original proofs and a considerable amount of new material. It was their desire to put the subject in the best possible form, adapted to the needs of second year high school students. A rather close connection with algebra is kept up during the year's work, and there is a good supply of practical problems and applications. In nearly all cases a proposition is followed by several exercises in which the theorem is applied, a most commendable procedure, and good lists of problems and exercises close each book. A careful reading of this text makes one feel that it is teachable. The arrangement of the material on the page and the choice of type, the paper and press work are excellent.

H. E. C.

Plane Trigonometry, With Tables, by C. I. Palmer and C. W. Leigh, Associate Professors of Mathematics in Armour Institute of Technology, Chicago. Pages x+156+132. 16x24cm. $1.50. 1914. McGraw-Hill Book Company, New York.

Those parts of trigonometry necessary to a proper understanding of the courses given in schools of technology are emphasized in this book. It can be used, however, in classical colleges and universities to advantage since the problems and applications require no knowledge of engineering subjects. The trigonometric functions are defined at once for any angle; considerable use is made of the line values of the functions; trigonometric equations are introduced early and used often; anti-trigonometric functions are used throughout the book; there is a chapter on complex numbers, series, and hyperbolic functions; and an unusually large number of practical problems and drill exercises is given. The tables are printed in unshaded type and are well arranged to avoid eye-strain. H. E. C.

Technical Geometry, Plane and Solid, by Horace W. Marsh, Head of the Department of Mathematics, School of Science and Technology, Pratt Institute. Pages xiv+244. 14x21 cm. $1.25. 1914. John Wiley & Sons, Inc., New York.

The demonstrations of the truths of geometry are here developed by each student, who learns to demonstrate by demonstrating. Very few figures are printed, and in Book I the theorems even are not stated. Under each theorem directions are given for drawing and constructing the figure and questions and suggestions indicate the line of proof to the student who is expected to work it out for himself. Each student prepares all the assigned work in a uniform work-book; and the careful study by the individual student and the exact record set down in the work-book seem to be the characteristic features of this method of the study of geometry. The three volumes of Marsh's "Constructive Textbooks of Practical Mathematics," Vol. I, "Industrial Mathematics," Vol. II, "Technical Algebra," Vol. III, "Technical Geometry," and Vol IV, "Technical Trigonometry," ought to be of considerable interest to all teachers of secondary mathematics. H. E. C.

Geometry of Four Dimensions, by Henry P. Manning, Ph. D., Associate Professor of Pure Mathematics in Brown University. Pages ix+348. 14x20 cm. $2.00. 1914. The Macmillan Company, New York.

The introduction gives a brief but interesting account of the geometry of more than three dimensions which dates back only to the first part of the nineteenth century. The book is planned to minimize as far as possible the difficulties of the subject. Among some of the means to accomplish this are: the synthetic method is adopted and analytic methods are not used as it is thought that the study of the figures themselves will help best to understand them; only four-dimensional space is considered; the pages are given a familiar appearance by following the arrangement of the usual textbook in plane geometry; the methods employed are those which the student has used freely in his previous work, even though he may not have understood their true significance and justification.

While the subject is difficult the method of presentation used by the author makes it possible for the teacher of secondary mathematics to read the book, and a study of it will undoubtedly be of great value to the teacher in his school work. A popular and non-mathematical discussion of the fourth dimension was published in 1908 with an introduction and editorial notes by Professor Manning. This book, "The Fourth Dimension Simply Explained," Munn & Co., $1.50, is a selection of twenty-five essays from 245 essays submitted for a prize of $500. H. E. C.

An Appeal Against Slaughter, by Marion E. Coville. 161 pages. 13x20 cm. Cloth. 1914. C. W. Bardeen, Syracuse, N. Y.

This book is intended as an appeal against the slaughter of animals for food by man. About sixty pages are given to arguments against slaughter. The remainder of the book—about 80 pages—is given over to a dictionary of quotations from the arguments of the earlier pages. This arrangement suggests that the author expects the book to be used as a sort of manual for believers in this doctrine. The appeal of the book is rather to the emotions than to reason. W. W.

Physiology and Hygiene With Practical Exercises, by Buell P. Colton, late Professor of Science in Illinois State Normal University and Louis Murbach of Detroit Central High School. Cloth. Illustrated. Pages x+388. 14x19 cm. Cloth. 1914. $1.00. D. C. Heath & Co., Boston.

This is a revision of Professor Colton's well known physiology by Dr. Murbach. Some important chapters have been re-written, while others have been rearranged, unifying correlated topics. A series of exercises have been appended to the chapters by the reviser which will add much to the value of the book.

Secondary school teachers of science have always appreciated Professor Colton's books for their clearness of statement and sound pedagogy. The revision has not changed this feature of the book, but has endeavored to make the book of still greater value by additions of exercises and other changes suggested as a result of use in classes. Mr. Murbach has been a sympathetic reviser and has done a good work in this revision. W. W.

Laboratory Outlines for Embryology, by Mary T. Harman, Ph. D., Assistant Professor of Zoölogy, Kansas State Agricultural College, vii+50 pages. 12x20 cm. Cloth. 1914. 50c net. P. Blakiston's Son & Co., Philadelphia.

This book gives an outline for laboratory lessons in embryology to occupy a term of twelve weeks and is designed to accompany recitation and lectures on the subject. The work necessarily covers only a limited amount of material—the topics being cell division, the spermatozoon, the cell, the chick and the pig embryo.

The directions are clear and definite and seem to be well adapted to beginners in embryology. W. W.

Das Mikroskop, von Prof. Dr. W. Scheffer, Berlin. Mit 99 Abbildungen im Text. Druck und Verlag von B. G. Teubner in Leipzig und Berlin 1914.

This is a small hand book on the microscope in the series of books issued by Teubner under the general heading "Aus Natur und Geisteswelt." It discusses first the history of the microscope, then the optics of the hand lens and compound microscope. There is also a chapter on the optics of the lighting arrangements and the mechanics of the stand. Another chapter is given to the devices for counting and measuring and the preparation of objects for the microscope including sectioning. For those wishing a compact handbook of the microscope this book will admirably meet the demand. W. W.

Das Meer, seine Erforschung und sein Leben, von Prof. Dr. Otto Lanson. Mit 40 Abbildungen. Druck und Verlag B. G. Teubner in Leipzig und Berlin 1914.

This is another volume of the series "Uns Natur und Geisteswelt." Some of the topics treated in this book of the sea are: History of modern explorations and studies of the sea; instruments used; the sea bottom and deposits; temperature conditions; movements; light and pressure; ap-

paratus used in studying life of the sea; plants; animals; adaptations of animals of the sea. It will be seen by the above list of topics that the book is a very comprehensive study of the sea done in the usual thorough and painstaking manner of the German author. W. W.

The Secrets of Success, for Boys and Young Men, by B. J. Kendall, M. D. 118 pages. Cloth. 50c. B. J. Kendall, M. D., Geneva, Ill.

A rather large portion of this book is devoted to advice on sex hygiene problems. Other topics are "intemperance," "choosing an occupation," "stability," "starting right," etc. This is a very good book for the purpose for which it is written. The author's arguments on sex hygiene questions might have been much stronger if he had had a scientific knowledge of the subject. However the book will do good, as its arguments will be easily understood by the uneducated as well as by those who have been more fortunate. W. W.

Food Products, by Dr. H. C. Sherman of Columbia University. 594 pp. 1914. Price $2.25. Macmillan and Co.

This is one of the few books which will be indispensable to the teacher of foods and home economics, whether she be in high school or in college work. It is a careful summary of recent knowledge on the subjects of food production and values. It includes a great deal of material which will be used in courses on sanitation, dietetics and applied chemistry, as well as in the more general food courses. It is remarkably complete both as to scientific detail and as to practical aspect. The bibliography at the end of each chapter gives the original sources from which the material is drawn; this feature alone, is sufficient to commend the book to students of home economics.

The style is so clear, and the subject matter so concisely presented, that the book will have wide use as a book of reference even for young high school students. M. C. D.

Briefer Physiology and Hygiene, by Colton and Murbach. 388 pages. 1914 Edition. D. C. Heath and Co., Boston.

So-called Physiology is usually taught in our secondary schools before Physics and Chemistry. With pupils limited thus in preparation it is a waste of time to attempt much in the way of scientific training. About all that can be expected is the dispensation of a little practical information. There are but very few texts adapted for this purpose. Among the best of these few is that under consideration. The authors of this text seem to have aimed chiefly to give the pupil knowledge that will stimulate him to take better care of his own body, and to take a wholesome interest in sanitation in general.

The authors have wisely attempted to include only so much anatomy and Physiology as is necessary to understand Hygiene. There is but one section that I should care to alter much in this respect, that is the section on the nervous system. In this section there is considerable matter that appears to me to be way beyond the grasp of the pupils that are usually found in the course. There are, moreover, some noted points that should either be eliminated or presented in a less positive way, e. g. those pertaining to location of "brain-functions" and "centers of sensation."

The arrangement of the subject matter is in general excellent. Beginning with the study of food, as the authors do after an introductory chapter, cannot fail to be much more interesting than the time honored custom of beginning with a study of the skeleton or any other anatomical feature. I even feel that most of the introductory matter consisting largely of definition might advantageously be distributed throughout the whole book, so as to get at the contents of the second chapter at once. The dis-

cussion of Amœba in this chapter is in my opinion of very questionable value. Its introduction in this place seems to violate the important pedagogical principle of proceeding from the more familiar to the less familiar. I fail to see in what way the brief description of Amœba and its physiology in this connection, can possibly help high school pupils to understand the human body and the processes that occur in it. If this matter is given at all it should be introduced in connection with the study of the various processes in the human body.

In teaching Physiology and Hygiene to boys and gir's I presume the two most difficult topics to handle refer to reproduction and to alcohol, narcotics, and other drugs. The latter our authors have approached in a sane fashion. It would however be advisable either to eliminate all questions concerning which there is still much difference of opinion or to present the principal arguments on both sides. Take e. g. the question concerning the food value of alcohol.

Sex hygiene, which is unquestionab'y one of the most important problems in the whole subject, they have omitted entirely. I cannot but feel that this omission is unwise. I believe that much could be accomplished even with young pupils by a brief study of reproduction in the plants and lower animals beginning with the simpler and proceeding to the more complex.

S. O. M.

Solid Geometry, by Sophia Foster Richardson, Assistant Professor of Mathematics in Vassar College. Pages v+209. 13x19 cm. 90 cents. 1914. Ginn & Co., Boston.

A study of solid geometry from the viewpoint of mathematics pure and strictly logical for college students is afforded by this book. That it is essentially clear will be admitted, no doubt, by the reader, but one might question the statement that it is essentialy simple. The treatment of the incommensurable case is based on that of the theory of limits grounded on the Dedekind-Cantor theory of irrational numbers. The arrangement permits the omission of this case if a teacher so desires. The definitions of surfaces and solids are given in their most general form; nearly all the proofs are given in full; there are 257 exercises, of which a few are numerical. The book is well arranged and printed, and the use of thin paper makes it of convenient size.

H. E. C.

Mathematics for Agricultural Students, by Henry C. Wollf, Ph. D., Assistant Professor of Mathematics, University of Wisconsin. Edited by Charles S. Slichter. Pages ix+309. 13x19 cm. $1.50. 1914. McGraw-Hill Book Company, New York.

Mimeographed notes of material for a working course in elementary mathematics in the College of Agriculture was tried out for three or four years before receiving its present form. This book may be used with any class of scientific students for a short course in mathematics beyond elementary algebra and geometry since it contains nothing of exclusive interest to agricultural students except some illustrations and exercises.

The material has been selected on the basis of its usefulness, and as it includes much not usually accessible to the student it is an excellent book for reference. Detailed directions are given for home work so that the student may learn to think out things for himself. The chapter headings are: Graphic Representation; Logarithms; The Circular Functions; The Triangle; The Ellipse; The Slide Rule; Statics; Permutations, Combinations, and the Binomial Expansion; Progression; Probability; Small Errors; Point, Plane and Line in Space; Maxima and Minima; Empirical Equations. Such a book presenting in clear and interesting fashion well-chosen topics for a year's study is very welc

H. E. C.

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Under this heading are published in the March, June, and October issues of this journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become a year old.

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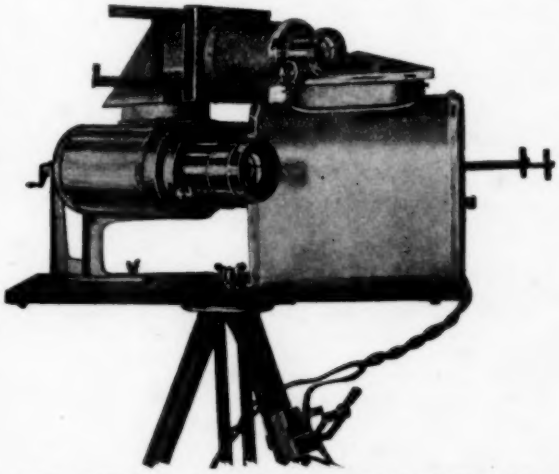
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